

## Chapter 2

### Program Description and Alternatives

Chapter 2 describes the program missions and the logic behind the structure of the program alternatives. Section 2.1 introduces the facility alternatives and options proposed to enhance the U.S. nuclear infrastructure and provide the capabilities needed to meet DOE's mission requirements. This section also presents the No Action Alternative and an alternative suggested by some of the public scoping comments. Sections 2.2 and 2.3, respectively, describe the operations necessary to implement DOE's program missions and the candidate sites and facilities where the operations would take place. Section 2.4 discusses the transportation activities associated with the program missions. Section 2.5 describes the alternatives that were considered reasonable for detailed evaluation. Section 2.6 explains why some other alternatives and facilities were considered and dismissed from evaluation in this NI PEIS. Section 2.7 summarizes the environmental impacts and implementation schedules associated with the alternatives that were evaluated and provides a comparative evaluation of alternatives. The chapter concludes with the status of a preferred alternative.

#### 2.1 INTRODUCTION

As discussed in Chapter 1, the U.S. Department of Energy (DOE) is proposing to enhance its existing nuclear facility infrastructure to accommodate new and expanding missions in the areas of nuclear research and development and isotope production. DOE currently does not have sufficient steady-state neutron sources to meet its projected irradiation needs for: (1) isotopes for medical and industrial uses, (2) plutonium-238 for use in advanced radioisotope (radioactive isotope) power systems for future U.S. National Aeronautics and Space Administration (NASA) space missions, and (3) other irradiation services to meet the Nation's nuclear research and development needs.

The programmatic alternatives focus on the use of irradiation facilities that are currently operating, could be brought on line, or could be constructed and operated to meet DOE's irradiation needs. Thus, this NI PEIS evaluates the following alternatives:

- **Alternative 1**, resuming operation of the Fast Flux Test Facility (FFTF) at the Hanford Site (Hanford) in Washington State;
- **Alternative 2**, using existing irradiation facilities (the Advanced Test Reactor (ATR) at Idaho National Engineering and Environmental Laboratory (INEEL), or the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL), or a generic commercial light water reactor (CLWR);
- **Alternative 3**, constructing and operating one or two new accelerators at an existing DOE site; or
- **Alternative 4**, constructing and operating a new research reactor at an existing DOE site.

This NI PEIS also evaluates a **No Action Alternative** in which the status quo would be maintained; that is, DOE's existing facilities would continue to meet their current mission requirements within their operating levels, but DOE would not enhance existing U.S. nuclear facility infrastructure or expand its current missions to accommodate new missions. This NI PEIS also includes an additional alternative which would permanently deactivate Hanford's FFTF without enhancing U.S. nuclear facility infrastructure to accommodate new or expanded missions. **Alternative 5**, FFTF deactivation, although a component of all alternatives except No Action and Alternative 1, is included as a stand-alone alternative in response to numerous public comments received during the scoping period.

This NI PEIS evaluates several options under each alternative. These options primarily involve DOE facilities that could be used for the fabrication, storage, and postirradiation processing of the targets necessary for the

program missions. Among the facilities proposed are: (1) the Radiochemical Engineering Development Center (REDC) at ORNL, (2) the Fluorine Dissolution Process Facility (FDPF) and/or Building CPP-651 (storage only) at INEEL, (3) the Fuels and Materials Examination Facility (FMEF) at Hanford, (4) Buildings 325, the Radiochemical Processing Laboratory (RPL), and Building 306-E at Hanford, and (5) a new facility to be constructed and operated at an existing DOE site to support the one or two new accelerators or new research reactor alternatives. **Table 2-1** provides an overview of the alternatives and 26 specific options for this *Draft Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility (Nuclear Infrastructure Programmatic Environmental Impact Statement [NI PEIS])*.

Sections 2.2 through 2.4 describe: (1) the operations needed to implement the program missions, (2) the candidate sites and facilities where the operations would take place, and (3) the transportation activities associated with the program missions. In describing the facilities, the sections refer to the specific alternatives for which the individual facilities are proposed. Detailed descriptions of alternatives are provided in Section 2.5. Alternatives considered and dismissed are discussed in Section 2.6. Section 2.7 summarizes the environmental impacts and schedules.

## **2.2 DESCRIPTION OF OPERATIONS**

### **2.2.1 Medical Isotopes Production**

Production of medical and industrial isotopes involves: (1) fabricating specially designed targets at a target fabrication facility, (2) irradiating the targets in an irradiation facility to generate specific medical isotopes, and (3) processing the targets at a target fabrication facility to prepare the medical isotopes for shipment to customers.

#### **2.2.1.1 Target Fabrication**

Each medical isotope would be produced using a target that is enriched in the appropriate target material for neutron irradiation. With the exception of the radium-226 target and those that use recycled materials, all of the targets use nonradioactive materials. Appendix C lists the types and forms of the target material used to produce each medical isotope.

After irradiation of the original target, radioactive impurities may remain with the target material after the medical isotope product is removed. Because of these impurities, reuse of the material can, in some cases, create targets that are radioactive. As a result, fabrication of targets from recycled target materials would require special handling and shielding.

Before beginning fabrication of a target for production of a particular medical isotope, a significant quantity of the element that makes up the target would be required. For nonradioactive targets, this material typically would be acquired from ORNL, where enrichment processes are conducted to produce target material that is sufficiently pure to support the generation of medical isotopes. The target form may be a metal, metallic oxide, or other chemical compound suitable for high-temperature irradiation, depending on engineering considerations such as material heat transfer characteristics, melting points, and metallurgical properties. The nonradioactive target material would be transported by truck from ORNL to the target fabrication facility. One candidate radioactive target material, radium-226, would not be supplied by ORNL. However, radium-226 could be supplied by a variety of sources (no decision on a proposed supplier or suppliers has been made at this time). Once materials for the targets arrive on the site, they would be stored at the target fabrication facility until needed for fabrication into medical isotope targets.

**Table 2–1 NI PEIS Alternatives and Options**

	Option Number	Irradiation Facility	Plutonium-238 Production Mission		Medical and Industrial Isotopes Production and Nuclear Research and Development Mission	
			Storage Facility	Target Fabrication and Processing Facility	Storage Facility	Target Fabrication and Processing Facility
<b>No Action Alternative</b>	1	—	—	—	—	—
	2	—	REDC	—	—	—
	3	—	CPP–651	—	—	—
	4	—	FMEF	—	—	—
<b>Alternative 1: Restart FFTF</b>	1	FFTF <sup>a</sup>	REDC	REDC	RPL/306–E	RPL/306–E
	2	FFTF <sup>a</sup>	FDPF/CPP–651	FDPF	RPL/306–E	RPL/306–E
	3	FFTF <sup>a</sup>	FMEF	FMEF	FMEF	FMEF
	4	FFTF <sup>b</sup>	REDC	REDC	RPL/306–E	RPL/306–E
	5	FFTF <sup>b</sup>	FDPF/CPP–651	FDPF	RPL/306–E	RPL/306–E
	6	FFTF <sup>b</sup>	FMEF	FMEF	FMEF	FMEF
<b>Alternative 2: Use Only Existing Operational Facilities</b>	1	ATR	REDC	REDC	—	—
	2	ATR	FDPF/CPP–651	FDPF	—	—
	3	ATR	FMEF	FMEF	—	—
	4	CLWR	REDC	REDC	—	—
	5	CLWR	FDPF/CPP–651	FDPF	—	—
	6	CLWR	FMEF	FMEF	—	—
	7	HFIR and ATR	REDC	REDC	—	—
	8	HFIR and ATR	FDPF/CPP–651	FDPF	—	—
	9	HFIR and ATR	FMEF	FMEF	—	—
<b>Alternative 3: Construct New Accelerator(s)</b>	1	New	REDC	REDC	New <sup>c</sup>	New <sup>c</sup>
	2	New	FDPF/CPP–651	FDPF	New <sup>c</sup>	New <sup>c</sup>
	3	New	FMEF	FMEF	New <sup>c</sup>	New <sup>c</sup>
<b>Alternative 4: Construct New Research Reactor</b>	1	New	REDC	REDC	New <sup>c</sup>	New <sup>c</sup>
	2	New	FDPF/CPP–651	FDPF	New <sup>c</sup>	New <sup>c</sup>
	3	New	FMEF	FMEF	New <sup>c</sup>	New <sup>c</sup>
<b>Alternative 5: Permanently Deactivate FFTF (with no new missions)</b>	—	—	—	—	—	—

a. Hanford FFTF would operate with mixed oxide fuel for 21 years and highly enriched uranium fuel for 14 years.

b. Hanford FFTF would operate with mixed oxide fuel for 6 years and highly enriched fuel for 29 years.

c. The new facility would not be required if a DOE site is selected with available support capability and infrastructure.

**Key:** 306–E, Hanford Building 306–E; ATR, Advanced Test Reactor at INEEL; CLWR, commercial light water reactor; CPP–651, INEEL Building CPP–651 Storage Vault; FDPF, Fluorine Dissolution Process Facility at INEEL; FMEF, Fuels and Materials Examination Facility at Hanford; HFIR, High Flux Isotope Reactor at ORNL; REDC, Radiochemical Engineering Development Center at ORNL; RPL, Radiochemical Processing Laboratory at Hanford.

Solid targets would be fabricated in gloveboxes using a series of mechanical and thermal processes. For the solid targets based on a powder, it is unknown at this time whether the powder would be loose or would be pressed and sintered into pellets. If the latter method is preferable, separate equipment would be required to press and sinter each type of solid target material to reduce the risk of cross-contaminating other target materials.

If pellets were used, the first major step in their preparation would be powder conditioning and pressing, which includes weighing, blending, and pressing the powder and binder into slugs. The slugs would be granulated, blended with binder addition, and pressed into pellets. The pellets would be transferred to the sintering/debind station, weighed, and subjected to a series of thermal processes to debind and sinter the pellets. The sintered pellets would be subject to characterization to ensure that specifications were met.

Acceptable pellets would be transferred to the loading and welding station to be visually inspected before inclusion into a capsule or pin. For both powder or pellet target materials, capsules and pins would be cleaned before final closure. The capsules would be leak-tested and inspected before being cleared for use.

#### **2.2.1.2 Target Irradiation**

Production of medical or industrial isotopes is accomplished by irradiating target materials in the neutron flux of an irradiation facility, such as a nuclear reactor. The desired isotopes are produced by neutron-induced reactions, such as activation or transmutation.

Activation is the most common neutron induced reaction and involves the capture of a neutron with the subsequent emission of a gamma ray. Since there is no change in the number of protons, the chemical identity of the target remains the same, for example, holmium-166 is produced by irradiating target material enriched in holmium-165 by activation.

Transmutation involves the capture of a neutron with the subsequent ejection of a proton or other particle that would change the chemical identity of the product, for example, phosphorus-32 is produced by irradiating a target material enriched in sulfur-32 by transmutation (proton ejection).

#### **2.2.1.3 Postirradiation Target Processing**

Processing of irradiated targets to recover medical- and industrial-grade isotopes can be broken down into distinct steps: (1) transport to and receipt of irradiated targets into a chemical separation facility; (2) chemical processing of the targets (using hot cells, shielded gloveboxes and appropriate open-faced hoods); (3) waste handling; (4) analysis of the products; (5) recycling of some of the target materials; and (6) shipment of the isotope products to customers.

Each of the medical isotope products evaluated for production is unique. Some targets would produce an isotope of the same element and would not require separation. Some targets would produce the same element, but would require some processing to remove impurities. Other target materials would produce different elements and would require chemical separation for separation of the target material, the desired isotope product, and unwanted impurities. Details on postirradiation processing of the targets for medical and industrial isotope production are provided in Appendix C.

#### **2.2.2 Plutonium-238 Production**

Production of plutonium-238 involves: (1) storage of neptunium-237, (2) fabrication of neptunium-237 targets, (3) irradiating the targets in an irradiation facility, and (4) processing the targets to prepare the plutonium-238

product for shipment to Los Alamos National Laboratory (LANL) where it would be fabricated into heat sources for radioisotope power systems. As stated in Section 1.2.2, a plutonium-238 production rate of 2 to 5 kilograms (4.4 to 11 pounds) per year would be sufficient to meet the estimated long-term requirements for NASA space exploration missions. Evaluations presented in this NI PEIS are based on a plutonium-238 production goal of 5 kilograms (11 pounds) per year to bound the environmental impacts of the proposed plutonium-238 production mission.

### **2.2.2.1 Target Fabrication**

The facility designated to fabricate neptunium-237 target elements for plutonium-238 production would receive the neptunium-237 oxide from the Savannah River Site (SRS) and would dissolve it in an acid solution prior to removal of protactinium-233, a decay daughter of neptunium-237. Protactinium-233 reaches 90 percent of its equilibrium activity approximately 90 days after purification and contributes significantly to radiation doses in the target fabrication line. The best approach for the removal of the protactinium-233 and possibly the easiest to implement, is to pass the neptunium solution through a column containing silica gel adsorbent (Wham et al. 1998). After protactinium-233 removal, the purified neptunium solution can be transferred to a target-fabrication glovebox line and reconversion of the neptunium to the oxide form can be initiated. The desired form of the oxide (microspheres) is obtained by loading the neptunium on a cation-exchange resin of the selected particle size range, washing the loaded resin, and using heated air to oxidize the resin and form the neptunium dioxide microspheres.

Current target designs for the ATR and HFIR reactors consist of neptunium dioxide blended with aluminum powder, pressed into a target core, and clad with aluminum. This type of target has been used in nearly all of the DOE production and research reactors (except for fast neutron flux reactors e.g., FFTF), to produce isotopes in general, and plutonium-238 specifically.

Three different techniques can be employed to fabricate such targets:

1. The neptunium dioxide and aluminum powders are blended and pressed into pellets. The pellets are then loaded into aluminum target tubes, which are seal-welded and hydrostatically compressed.
2. The neptunium dioxide and aluminum powders are blended and pressed into compacts. The compacts are then roll-milled between aluminum cladding, after which the aluminum-clad neptunium dioxide is seal-welded.
3. The neptunium dioxide and aluminum powders are blended and pressed into billets and assembled into welded and evacuated aluminum containers. The billets and containers are then coextruded to produce target tubes.

All three techniques have advantages and disadvantages. The coextrusion technique has been used successfully by SRS in its plutonium-238 program and other special isotope programs. Demonstrations of the fabrication techniques would be required to determine which techniques are best for the proposed irradiation facilities.

The target blanket for the high-energy accelerator consists of neptunium dioxide blended with aluminum powder, pressed into the required configuration, and clad with aluminum.

Targets for CLWR would have stainless steel or Zircaloy cladding due to the higher operating temperatures. The postirradiation processing of these targets would be different from the postirradiation processing of the aluminum-clad targets.

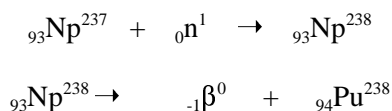
The targets used for production of plutonium-238 in FFTF would be similar to target concepts developed in studies performed in 1992 and 1993. The proposed target assembly consists of 19 large diameter pins that combine alternating thin pellets or wafers of neptunium dioxide and yttrium hydride moderator within a ferritic alloy steel cladding. The steel cladding is required for compatibility with the reactor sodium.

The conversion efficiency of neptunium-237 to plutonium-238 during target irradiation at FFTF, ATR, HFIR, or CLWR is approximately 10 to 15 percent. Approximately 50 kilograms (110 pounds) per year of neptunium-237 would be fabricated into targets to meet the plutonium-238 production goal of 5 kilograms (11 pounds) per year. Following processing of the irradiated targets, approximately 40 kilograms (88 pounds) per year of the unconverted neptunium-237 would be stored in liquid form and recycled for the fabrication of new targets. The remainder would be process waste. Based on the current preconceptual designs, the conversion efficiency of neptunium-237 to plutonium-238 during target irradiation at the new high-energy accelerator and new research reactor is significantly lower, approximately 2.8 percent and 1.4 percent respectively. To meet the plutonium-238 production goal of 5 kilograms (11 pounds) per year, approximately 180 kilograms (396 pounds) would be fabricated into targets annually for irradiation in the high-energy accelerator and 380 kilograms (836 pounds) would be fabricated into targets for irradiation in the new research reactor. The neptunium-237 target fabrication requirements for the new research reactor can be reduced by a factor of 4 to 8 with refinements to the current target and reactor preconceptual designs presented in Appendix E.

Neptunium must be treated like uranium-235 under DOE safeguards and security requirements. The requirements are based on the mass of neptunium and the attractiveness level of the physical and chemical form of the neptunium. This would require special security clearances for those people having access to the neptunium and ongoing security reviews and audits during the time of possession of the neptunium (McCallum 1999). Safe, secure trailer/SafeGuards Transport (SST/SGTs) will be required to transport any significant quantity of neptunium. The neptunium containers would be stored in specially designed storage vaults to provide a secure, safe storage for the materials. DOE guidelines concerning safeguards and security would be followed during the times materials were stored or being processed.

#### **2.2.2.2 Target Irradiation**

Irradiation of neptunium-237 targets in neutron flux produces plutonium-238 according to the following equations:



The neptunium-237 target nuclide absorbs a neutron to become neptunium-238, which in turn decays in the second equation with a half-life of 2.1 days and the emission of a beta particle (or electron) to form plutonium-238.

Irradiation of the neptunium-237 targets generates fission products in the targets. The irradiated targets would be cooled for at least 120 days to allow time for the decay of short-lived fission products (e.g., iodine-131). Following the cool-down period, the irradiated targets would be loaded into a shielded cask for transport to the chemical processing facility. They would then be ready for chemical processing to separate the plutonium-238 content and unconverted neptunium-237 from radioactive waste products.

### 2.2.2.3 Postirradiation Target Processing

The flowsheet for processing irradiated neptunium-237 targets, recovering the unconverted neptunium-237, refabricating target elements, separating the plutonium-238 product, and shipping the plutonium-238 for fabrication into heat sources for radioisotope power systems is shown in **Figure 2–1**. Processing the irradiated neptunium-237 targets would be conducted inside heavily shielded hot cells to protect workers from high radiation doses. Hot cells are specially designed shielded vaults or areas used for the remote handling and manipulation of some radioactive materials. Certain chemical processing steps would be required to recover the plutonium-238 as product and to recover the neptunium-237 for recycle. At ORNL and Hanford this process would be accomplished in two steps:

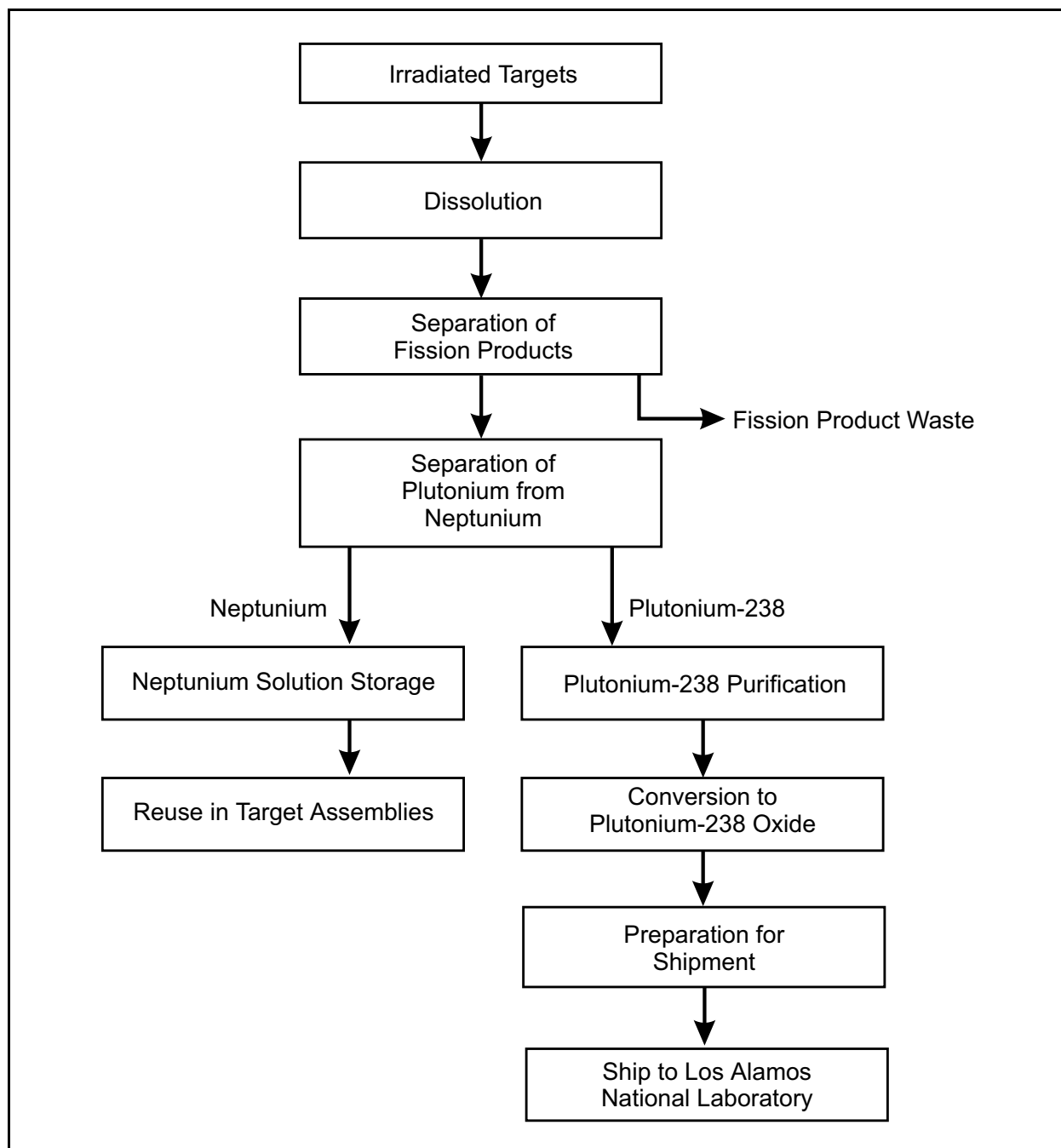
- For targets irradiated in ATR or HFIR, caustic-nitrate solution would be used to dissolve the cladding, thereby separating the bulk of the aluminum and caustic-soluble fission products from the actinide products, including the neptunium and plutonium. For targets irradiated in FFTF or a CLWR, the first step in the target processing would be to chop the targets into small pieces for dissolution in acid in the next step.
- Next, acid would be used to dissolve the actinide products and remaining fission products to prepare the feed for the first mainline separation process. The feed would be filtered prior to pH (acidity/alkalinity) adjustment to remove any solids that could complicate the solvent extraction process. For the FFTF or CLWR targets, the undissolved cladding would be discarded as waste.

Dissolution of the irradiated targets at INEEL would be accomplished using a one-step target dissolution process in a nitric acid-fluoroboric acid solution instead of the two-step process for the ATR and HFIR targets that would be used at ORNL and Hanford. It would still be necessary to shear or chop the FFTF or CLWR targets at INEEL before the acid leach process.

Subsequent to target dissolution, a tributyl phosphate-based solvent extraction process would be used for three cycles of purification. The first cycle would decontaminate the neptunium and plutonium products from fission product wastes. The second cycle solvent extraction process would separate the neptunium from the plutonium, and the third-cycle process would remove trace plutonium from the neptunium product. The plutonium-238 product would undergo further purification using anion exchange if the product does not meet specification.

Chemical conversion of the plutonium to an oxide starts with its precipitation from solution as an oxalate. The precipitate is filtered and calcined (heated at high temperature) to an oxide product. The plutonium dioxide product is further treated in an oxygen-exchange process to exchange its oxygen-17 and oxygen-18 components with oxygen-16, thereby reducing the neutron emission rate. The resulting oxide product would be packaged and shipped to LANL for fabrication into heat sources for radioisotope power systems.

The purified neptunium nitrate from the third-cycle solvent extraction process would be stored as a solution. A small quantity of neptunium oxide (6 to 8 kilograms [12 to 16 pounds]) would be removed from storage, dissolved, and purified to replace the neptunium-237 that was converted to plutonium-238. This material would be added to the neptunium solution recovered during postirradiation target processing, loaded onto a cation-exchange resin, and then calcined to produce oxide microspheres for re-use in target assemblies for irradiation. Waste-handling equipment used to minimize the activity in low-level radioactive liquid waste and for stabilizing solid wastes into an acceptable waste form would be included in the hot cells used for the chemical processing of irradiated targets.



**Figure 2–1 Chemical Processing Flowsheet for Irradiated Neptunium-237 Target Processing**

### 2.2.3 Nuclear Research and Development

As discussed in Section 1.2.3, nuclear research and development initiatives requiring an enhanced DOE facility infrastructure fall into three basic categories: materials research, nuclear fuel research, and advanced reactor development.

## 2.3 DESCRIPTION OF FACILITIES

This section provides a description of the facilities proposed to be used by DOE for the production of medical and industrial isotopes, plutonium-238, and nuclear research and development. Because the programmatic alternatives are structured around the use of the candidate irradiation facilities, they are discussed first in Section 2.3.1, followed by a discussion of the proposed target fabrication and processing facilities in Section 2.3.2. The proposed irradiation facility alternatives are: (1) FFTF at Hanford, (2) ATR at INEEL, (3) HFIR at ORNL, (4) a generic CLWR, (5) one or two new accelerators at an existing DOE site or (6) a new research reactor at an existing DOE site.

### 2.3.1 Target Irradiation Facilities

#### 2.3.1.1 Fast Flux Test Facility

FFTF is a 400-megawatt thermal, liquid-cooled (sodium) nuclear test reactor (**Figure 2–2**) that is owned by DOE and is located at the Hanford Site in southeastern Washington State near Richland, Washington. Figure 3–6 presents a map of Hanford that depicts the location of FFTF. In May 1972, the U.S. Atomic Energy Commission published an Environmental Statement for FFTF (AEC 1972). That document provided information on the potential environmental impacts associated with the construction and operation of FFTF. In the late 1970s, the Safety Analysis Report prepared for FFTF was reviewed by the U.S. Nuclear Regulatory Commission (NRC) and the Advisory Committee for Reactor Safeguards. Comments from both organizations were addressed in the FFTF Final Safety Analysis Report. The construction of FFTF was completed in 1978.

Following extensive testing, FFTF was started in April 1982. During its operation, FFTF successfully tested advanced nuclear fuels, materials, components, operating protocols, and reactor safety designs. FFTF also produced a wide variety of medical isotopes and made tritium for the U.S. fusion research program.

FFTF was originally designed and operated as a science test bed for U.S. liquid metal fast reactor



**Figure 2–2 Fast Flux Test Facility**

programs. These programs, which were canceled in 1993, were key elements both in closed fuel cycle and actinide waste disposition technology development. In December 1993, DOE decided not to operate FFTF

due to a lack of economically viable missions at that time. In accordance with the National Environmental Policy Act (NEPA), DOE published an environmental assessment and Finding of No Significant Impact for the shutdown and deactivation of FFTF in May 1995 (DOE 1995a). The environmental assessment contained an evaluation of the environmental impacts associated with the actions necessary to place FFTF in a radiologically and industrially safe shutdown condition suitable for long-term surveillance and maintenance before final decontamination and decommissioning.

The FFTF complex includes the reactor, as well as equipment and structures for heat removal, containment, reactor safety and shutdown systems core component handling and examination, fuel offloading and storage, utilities, and other essential services. The central structure of FFTF is the reactor containment building, an all-welded cylindrical steel structure 41 meters (135 feet) in diameter and 57 meters (187 feet) high. The array of buildings and equipment that surround the containment building and comprise the FFTF complex is shown in **Figure 2–3**. The reactor is located below grade in a shielded cell in the center of the containment structure. Heat is removed from the reactor by circulating liquid sodium under low pressure through three separate closed primary piping loops, which include pumps, piping, and intermediate heat exchangers. These loops are located within inerted cells (cells filled with inert gases) within the containment structure. **Figure 2–4** is a cutaway of the containment building showing the location of the reactor, primary pumps, and intermediate heat exchangers. Three secondary sodium loops transport reactor heat from the intermediate heat exchangers to the air-cooled tubes of the dump heat exchangers. From there, the heat dissipates into the atmosphere through the forced draft dump heat exchanger. Commercial nuclear power reactors use reactor heat to create steam, which turns a turbine to produce electricity. FFTF, however, does not generate electricity.

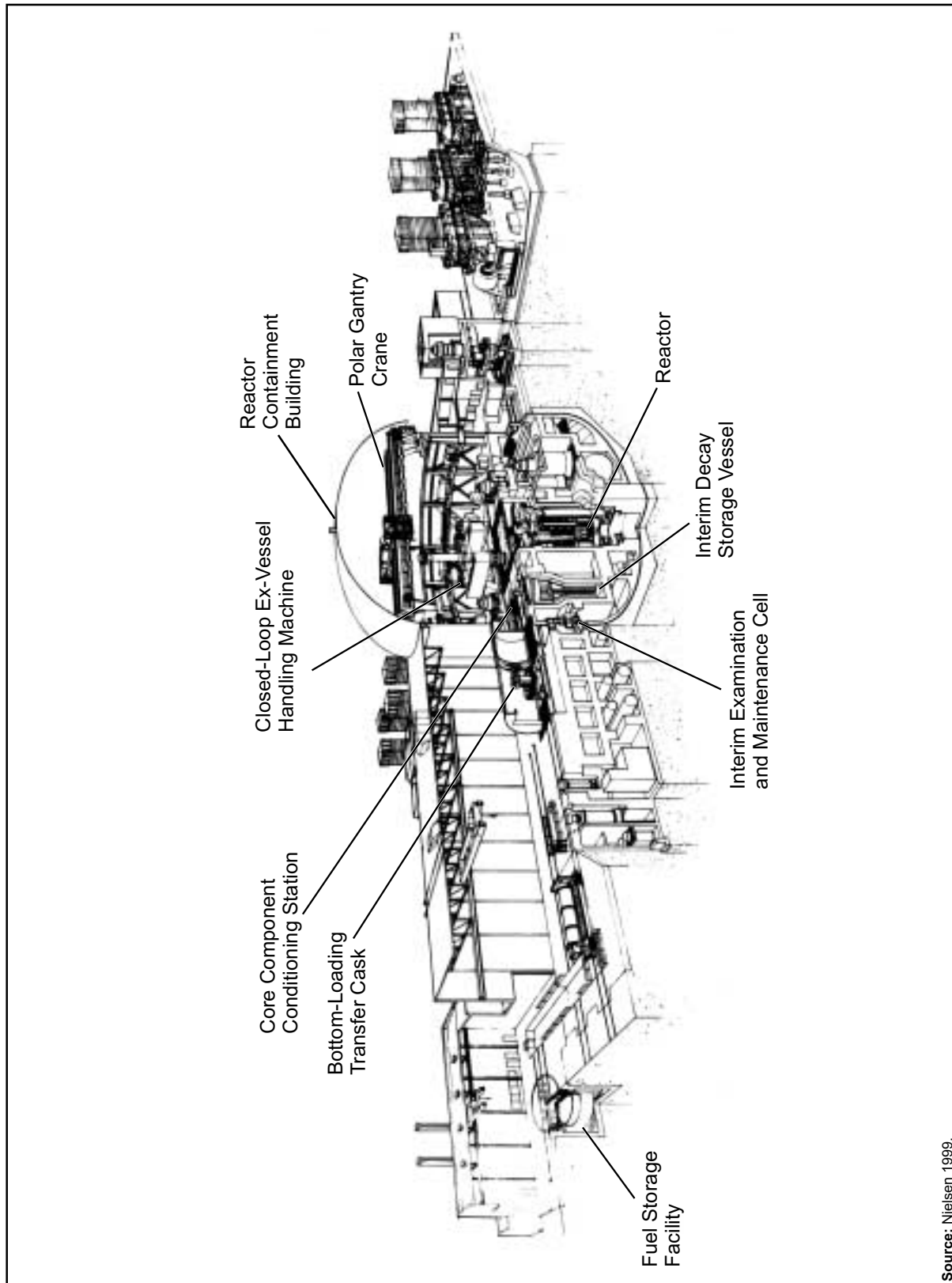
FFTF has demonstrated its capability to function as a nuclear science and irradiation services user facility. It has five distinct features: size, flux, test evaluation and irradiation capabilities, fuel type, and coolant type. In combination, these features provide a multipurpose facility suitable for medical and industrial isotopes production, plutonium-238 production, and nuclear research and development purposes. Although FFTF was used primarily to evaluate reactor fuels and different fuel assembly materials during its 10 years of operation, the reactor facility has also supported large and varied test programs for industry, nuclear energy (domestic and international), medical isotope applications and research, space nuclear power and fusion research programs. A more detailed description of FFTF and its capabilities is included in Appendix D.

#### **2.3.1.1.1 Maintenance of FFTF in Standby**

FFTF is currently defueled and is being maintained in a safe standby condition. FFTF would be maintained in the standby condition in the No Action Alternative. Seventy-seven of the 100 systems are operational; the other 23 are in a recoverable standby state. System integrity and configuration control are being maintained. The Main Heat Transport System is being operated at approximately 200 °C (400 °F) to keep the sodium coolant in the reactor liquefied and circulating. Essential systems, staffing, and support services are being maintained in a manner that would support potential restart.

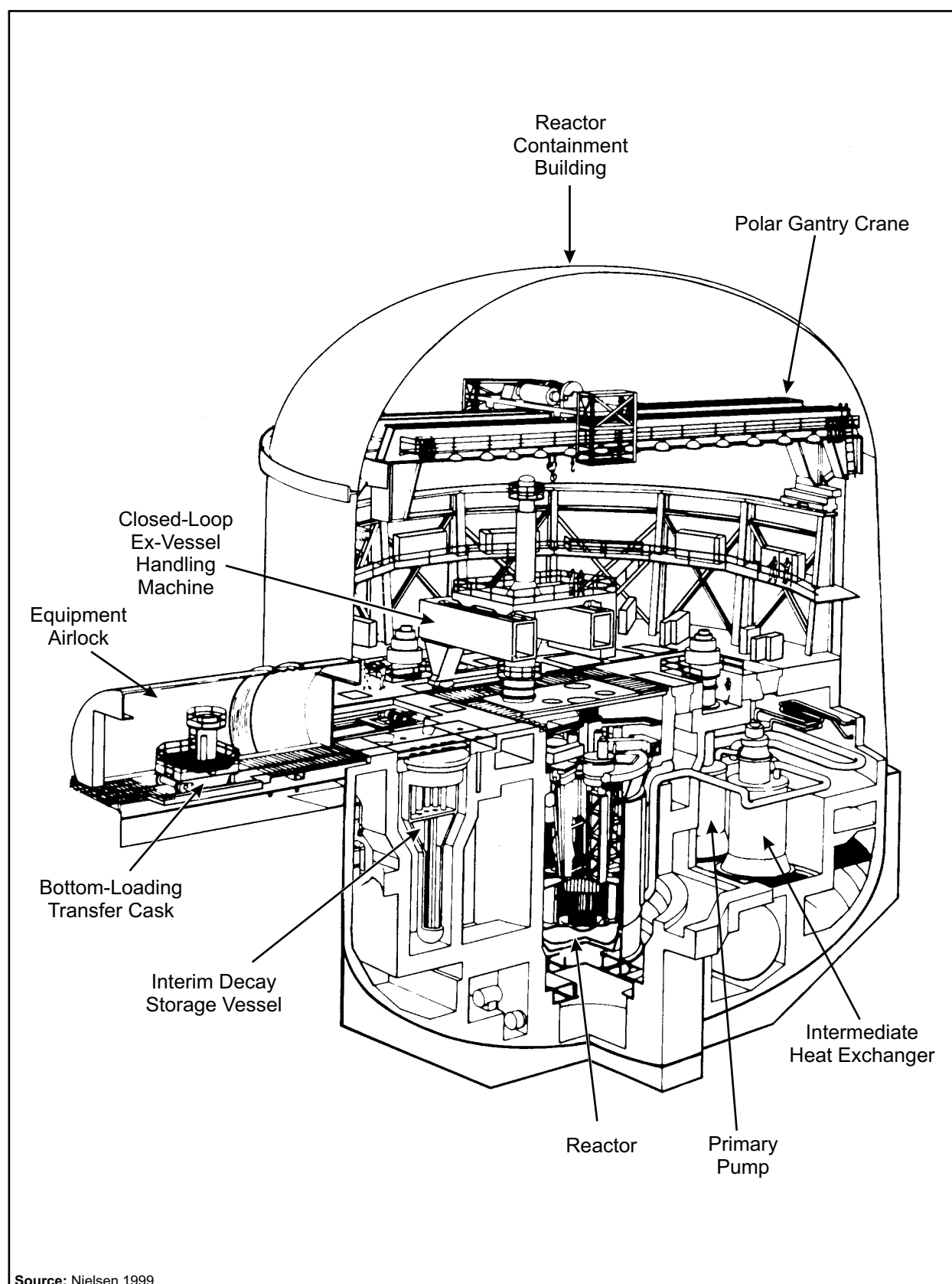
#### **2.3.1.1.2 FFTF Restart and Operation**

FFTF is proposed to be restarted and operated in Alternative 1, FFTF Restart. If a decision were made to restart FFTF, several equipment upgrades are planned to return systems to operation, improve reliability, conform to current standards, improve efficiency, and minimize waste. Most of the required modifications would consist of either mechanical equipment upgrades or replacement of outdated control and computer



Source: Nielsen 1999.

Figure 2-3 FFTF Complex



**Figure 2-4 Cutaway of the Reactor Containment Building**

systems and would have minimal environmental consequences. The following is a brief list of the planned modifications if FFTF would be restarted (PNNL 1999).

- Upgrade of plant protection system (scram breakers, power supplies, and signal conditioners)
- Replacement of zero-time-outage motor generator sets with solid-state electronic units
- Upgrades of plant data systems computers
- Upgrade of conductivity metering system on three cooling towers and replacement of electronic sensors and controls
- Installation of two new electrical distribution transformers to replace the polychlorinated biphenyl-filled units that were removed during standby operations
- Establishment of a program to assess and replace elastomer seals during the startup period to take advantage of advancements in seal technology
- Upgrades of the plant simulator (A program to upgrade the existing simulator to reach commercial simulator standards was in progress, but was discontinued when FFTF was placed in standby.)

#### **2.3.1.1.3 FFTF Fuel Use Option**

This NI PEIS postulates that FFTF would operate at a nominal power level of 100 megawatts, one quarter of the reactor design power level, to meet the irradiation requirements of the proposed missions. Periodic increases in power level between 100 and 400 megawatts may be required to support nuclear research and development activities. Operating FFTF at a nominal 100-megawatts power level extends the reactor life and significantly reduces the generation rate of spent fuel. FFTF is currently designed to operate using mixed oxide fuel (i.e., plutonium-uranium), however, it can also be operated using highly enriched uranium fuel. FFTF has an onsite supply of mixed oxide fuel for approximately 6 years of operation at the 100-megawatt level proposed for the mission (see Section 2.3.1.1.4). When this onsite fuel is depleted, FFTF may continue to use mixed oxide fuel or may switch to a reactor core of highly enriched uranium fuel. DOE believes that an additional 15-year supply of mixed oxide fuel would be available from Germany under favorable economic terms, (i.e., no charge for the fuel). The fuel would be reconfigured into assemblies suitable for irradiation at FFTF before shipment to the United States. That is why this NI PEIS evaluates the operation of FFTF for two reactor core configurations for the 35-year evaluation period of operation common to all alternatives: (1) operation of a mixed oxide core for approximately 21 years followed by 14 years of operation with a highly enriched uranium core, and (2) operation of a mixed oxide core for approximately 6 years followed by 29 years of operation with a highly enriched uranium core.

In this NI PEIS, DOE has not evaluated the possibility of using low-enriched uranium fuel for operation of the FFTF because it makes programmatic and economic sense to use available mixed oxide fuel supplies before using uranium. U.S. nonproliferation policy (U.S. House of Representatives 1992 [Schumer Amendment]), strongly discourages the use of highly enriched uranium fuel in civilian research and test reactors. The Reduced Enrichment for Research and Test Reactors Program implements this policy by developing technical means to reduce and eventually eliminate the use of highly enriched uranium in research and test reactors throughout the world and in the United States, without decreasing their safety or significantly affecting their performance and operating costs.

To be in compliance with these policy directives, the most appropriate fuel supply for FFTF in the out-years (beyond current Hanford mixed oxide and possible SNR-300 mixed oxide supplies) must be determined by a technical study with the preferred fuel source being low-enriched uranium. Highly enriched uranium fuel should only be considered if low-enriched uranium is not technically feasible, or if there are significant impacts on safety, performance, or cost associated with using fuels other than highly enriched uranium.

In the event that a decision is made to restart the reactor, and to support these policy directives, DOE's Office of Nonproliferation and National Security would undertake a study to consider the technical feasibility of low-enriched uranium fuel (under the Reduced Enrichment for Research and Test Reactors Program) for FFTF. If low-enriched uranium fuel is found infeasible, DOE would subsequently procure highly enriched uranium fuel in a manner consistent with U.S. nonproliferation policy. This study would be conducted, decisions implemented, and fuel made available during the time period between a Record of Decision indicating an FFTF restart and prior to the end of available Hanford mixed oxide and possible SNR-300 mixed oxide fuel supplies.

For the purposes of presenting a bounding analysis in this PEIS, DOE has analyzed the impacts of using highly enriched uranium fuel in FFTF after the available mixed oxide fuel supplies have been expended. These impacts would bound those of using a low-enriched uranium fuel form.

#### **2.3.1.1.4 FFTF Irradiation Operations**

There are eight locations available in the reactor core that are termed Open Test Assembly positions. These positions are located under spool pieces in the reactor head and allow the installation of 38-foot-long assemblies that extend from the reactor head down to the reactor core. These eight locations are unique from the rest of the reactor in that they allow direct, contact instrumentation for remote monitoring during reactor operation. Within the 82 active core locations, there are up to 20 or more additional locations that could contain a standard length (3.6-meter or 12-foot) test assembly. These locations also have specific on-line outlet temperature and flow measurements from installed plant instrumentation. In addition to the test locations within the active fueled region of the core, there are 108 locations available in the surrounding reflector region where other tests could be inserted. These three basic testing configurations enable irradiation of large and/or very diverse quantities. The target designs vary according to the test requirements and the location of the test within the reactor.

To fulfill the mission, the FFTF core would be modified to include an array of target assemblies and rapid radioisotope retrieval systems capable of producing a number of long- and short-lived isotopes for medical and industrial applications and plutonium-238 for space power applications. In addition, reactor space would be provided for research and development test articles.

Fifteen plutonium-238 production targets would be included in the reflector region with an annual production rate of 5 kilograms. The residence time for these targets would be three 100-day cycles with five assemblies being harvested at the end of each cycle.

Long-Term Irradiation Vehicles would be used to irradiate targets to produce long-lived isotopes. The Long-Term Irradiation Vehicles would be installed in the reactor during normal refueling operations and would be handled using standard FFTF component handling equipment. The Long-Term Irradiation Vehicle would consist of a bundle of target pins installed inside a nozzle, duct, and handling socket assembly similar in appearance to an FFTF 3.6-meter-long (12-foot-long) fuel assembly. Depending on the isotopes to be produced, the pin bundle could contain moderator pins and neutron shield pins. A design that would allow re-use of the long-term irradiation assembly nozzle, duct, and handling socket hardware would be considered during the design process to reduce both costs and waste generation. It is assumed that 12 Long-Term

Irradiation Vehicle assemblies for the production of long-lived medical and industrial isotopes would be installed. A detailed description of the Long-Term Irradiation Vehicles and their proposed use is included in Appendix C.

Rapid radioisotope retrieval systems would be installed in selected Open Test Assembly positions for the production of short-lived isotopes. These systems would extend from above the spoolpieces in the reactor head down into and slightly below the active core region and would allow target materials to be inserted and withdrawn from the reactor core region while the reactor is operating. Systems for routinely inserting and removing irradiation targets, nuclear instrumentation, and research hardware have been in use for years at various research reactors throughout the world. Most of these systems use either a pneumatic rabbit-type system or a mechanical cable-type system for insertion and retrieval. There would be a maximum of eight systems in the core. One of the systems would be configured as a gas target to produce iodine-125 from xenon-124. The other seven systems would be used to produce solid short-lived medical isotopes. A detailed description of the rapid radioisotope retrieval systems and their proposed use is included in Appendix D.

FFTF would operate at a nominal power level of 100 megawatts. However, the accident analyses provided in this NI PEIS are based on the FFTF design power level of 400 megawatts and provide conservative estimates of operation at 400 megawatts-thermal and lower power levels.

Testing programs would be conducted for new materials and target designs to be irradiated in the reactor. A discussion of the types of testing that would be associated with the medical isotope and plutonium-238 production missions is included in Appendix D.

#### **2.3.1.1.5 FFTF Deactivation**

FFTF would be permanently deactivated in Alternative 2 (Use Only Existing Operational Facilities), Alternative 3 (Construct New Accelerator[s]), Alternative 4 (Construct New Research Reactor), and Alternative 5 (Permanently Deactivate FFTF). This would require placement of FFTF in a radiologically and industrially safe shutdown condition that is suitable for a long-term surveillance and maintenance phase prior to final decontamination and decommissioning. An *Environmental Assessment - Shutdown of the Fast Flux Test Facility, Hanford Site, Richland, Washington*, issued by DOE in 1995, addressed the environmental impacts associated with permanently deactivating FFTF (DOE 1995a).

If a decision were made to proceed with permanent deactivation of FFTF, the molten sodium (radioactive) would be removed from the reactor systems and transferred to an existing sodium storage facility that was specially constructed for this purpose. The sodium would be drained by pressure transfer to the maximum practical extent into tanks located in the sodium storage facility. Residual sodium would be accommodated to a stabilized condition so that long-term monitoring and surveillance could be conducted in a safe and environmentally sound manner. The current concept for accommodating residuals would be to maintain an inert gas atmosphere that prevents any chemical reactions during long-term surveillance and maintenance.

#### **2.3.1.2 Advanced Test Reactor**

ATR is a light-water-cooled and moderated reactor with a design thermal power of 250 megawatts that is owned by DOE and is in the Test Reactor Area in the southwest portion of INEEL. Figure 3–3 presents a map of INEEL that depicts ATR's location.

ATR would continue to operate and meet its current mission requirements, including naval reactor research and development, medical and industrial isotope production, and nuclear research and development activities, at its current operating levels in the No Action Alternative, Alternative 1 (FFTF Restart), Alternative 3

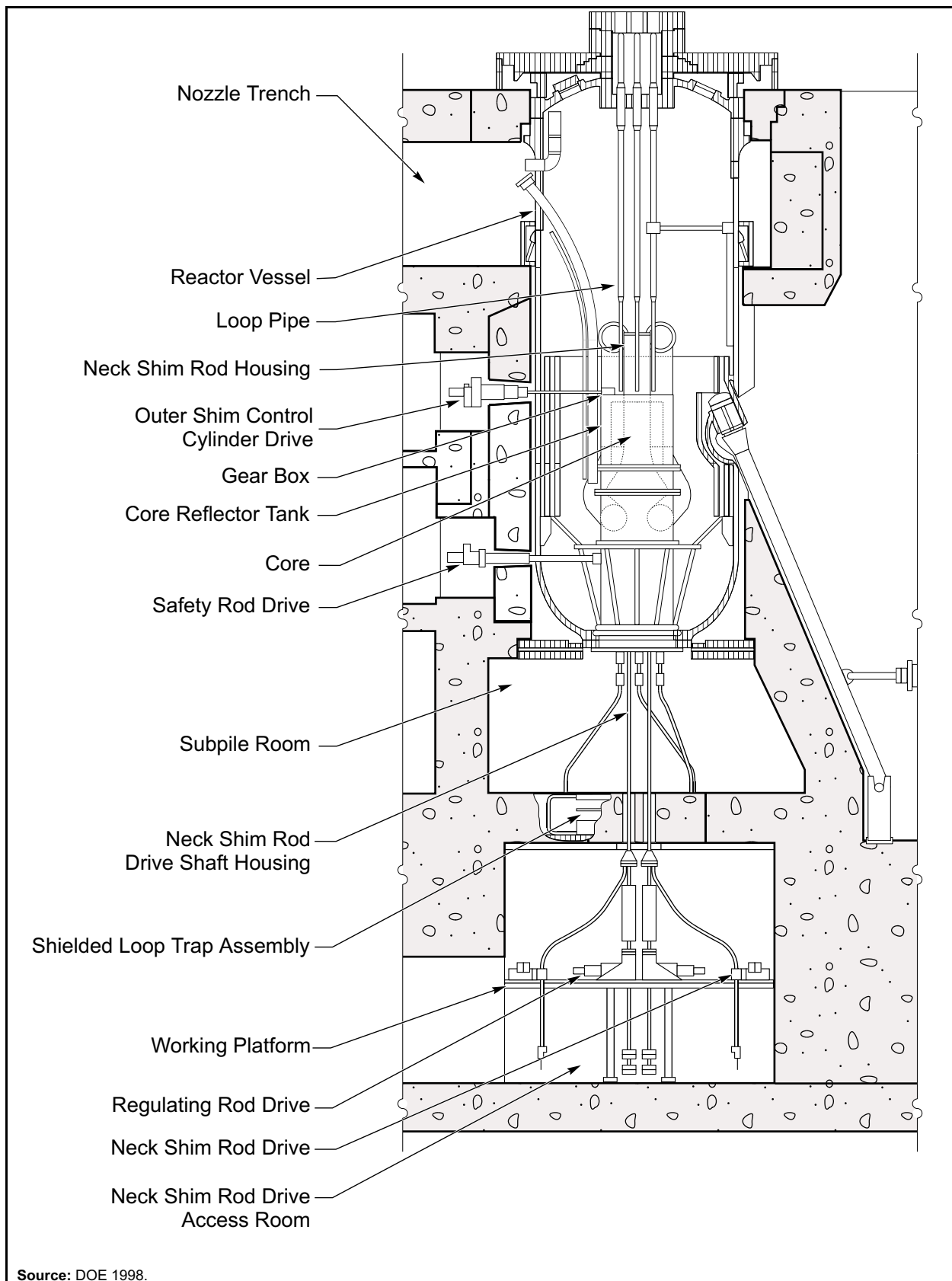
(Construct New Accelerator[s]), Alternative 4 (Construct New Research Reactor), Alternative 5 (Permanently Deactivate FFTF), and Alternative 2 (Use Only Existing Operational Facilities) when it is not providing irradiation services in support of the plutonium-238 production mission. When ATR is supporting the plutonium-238 production mission, it would fully support its primary mission, naval reactor research and development; however, it would support the medical and industrial isotope production and nuclear research and development activities to the extent possible within its current reactor operating levels. Consideration must be given to the need to maintain appropriate levels of neutron flux to support ATR's primary mission. Neutron flux levels can be impacted by the placement of targets, such as neptunium-237 targets for the production of plutonium-238, in the reactor core. The production planning assumption for ATR is from 3 kilograms (6.6 pounds) of plutonium-238 per year (if used in conjunction with HFIR) to 5 kilograms (11 pounds) of plutonium-238 per year (if ATR were used alone). Thus, ATR alone could meet the program goal of 5 kilograms (11 pounds) per year and could be used in combination with any one of the three processing facilities for the plutonium-238 production mission.

Special features of ATR include high neutron flux levels (ranging from  $1 \times 10^{15}$  neutrons per square centimeter per second in the flux traps to  $1 \times 10^{13}$  neutrons per square centimeter per second in the outer reflector positions) and the ability to vary power to fit different experiment needs in different test positions. The primary user of ATR is the U.S. Naval Nuclear Propulsion Program. A variety of other users include other foreign and domestic government programs, a commercial isotope production company, industrial customers, and research and development interests. This facility description is based on information provided in the *Advanced Test Reactor Upgraded Final Safety Analysis Report* (LMIT 1997) and *Capabilities of the Test Reactor Area Featuring the Advanced Test Reactor* (LMIT 1998). A number of support facilities are important to the operation of ATR (LMIT 1997). Among these are the Advanced Test Reactor Critical Facility, which is used to baseline experiment impacts to the ATR flux profile, and the Nuclear Materials Inspection and Storage facility, which is used to receive, store, and inspect reactor fuel prior to its placement in ATR (INEEL 1999, 2000; LMIT 1998).

The reactor, its primary coolant system, control room, and much of its auxiliary and experimental support equipment are in the Test Reactor Area Building 670. ATR began operation in 1967 and is expected to continue operating for several decades. The reactor vessel is entirely stainless steel and the core internals are replaced every 7 to 9 years. The most recent changeout was completed in 1994 (LMIT 1998). Buildings and structures in other parts of the Test Reactor Area provide additional support functions.

ATR is a light-water-cooled and -moderated reactor with a design thermal power of 250 megawatts and typically operates at approximately 140 megawatts or less. ATR operates with highly enriched uranium fuel. Typical operating cycles are 42 days or 49 days at power followed by a 7-day outage for refueling and changeout of experiments and isotope production targets. The core is 1.2 meters (4 feet) high and is surrounded by a 1.3-meter-diameter (4.25-foot-diameter) beryllium reflector. Beryllium is an excellent neutron reflector and is used to enhance the neutron flux essential to a test reactor. The location of the core in the ATR vessel is shown in **Figure 2-5**. ATR has nine flux traps in its core and achieves a close integration of flux traps and fuel by means of a serpentine fuel arrangement (**Figure 2-6**). When viewed from above, the ATR fuel region resembles a four-leaf clover. The four flux traps positioned within the four lobes of the reactor core are almost entirely surrounded by fuel, as is the center position. Four other flux trap positions between the lobes of the core have fuel on three sides. ATR's unique control device design permits large power shifts among the nine flux traps. Testing can be performed in test loops installed in some flux traps with individual flow and temperature control or in reflector irradiation positions with primary fluid as coolant. The curved fuel arrangement brings the fuel closer on all sides of the test loops than is possible in a rectangular grid.

ATR is configured with nine flux traps. Five of the flux traps are configured with pressurized-water loops that allow for individual temperature, pressure, flow, and chemistry controls. The five test loops are used by



**Figure 2-5 Vertical Cross Section of the ATR Vessel**

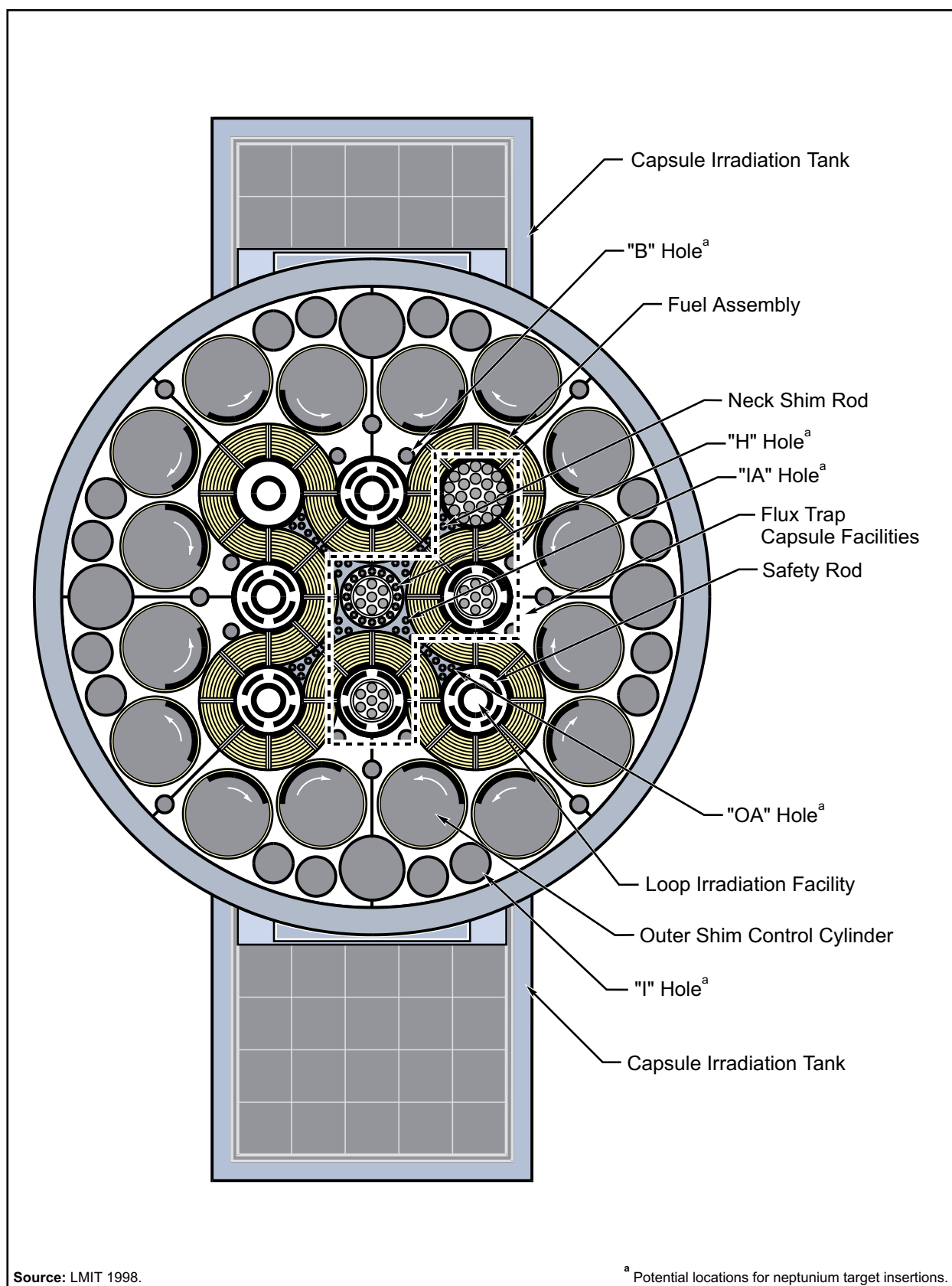


Figure 2-6 Plan View (Cross Section) of ATR

the Naval Reactors program. Of the remaining four flux traps, one is dedicated to the Naval Reactors program, one is used for isotope production, one is used for low-specific-activity cobalt production, and the fourth has recently had the Irradiation Test Vehicle installed. The Irradiation Test Vehicle can be described as three small pressurized-gas test loops. The use of one of these three test loops was recently purchased by a British corporation; negotiations for use of the other two are currently under way.

In addition to the primary flux trap irradiation positions, there are some 70 irradiation positions in the beryllium reflector (and aluminum support structure) that are available for experiment irradiation and isotope production. These position diameters range from 15.9 millimeters (0.625 inch) to 127 millimeters (5.0 inches) with thermal neutron flux levels ranging from  $1 \times 10^{15}$  neutrons per square centimeter per second to  $1 \times 10^{13}$  neutrons per square centimeter per second. Approximately 25 percent of the high-flux test positions (A holes, B holes, and H holes) are currently used for iridium-192 production. The majority of the remaining high-flux test positions are used for cobalt-60 production. Occasionally, additional isotopes (e.g., strontium-89, nickel-63) are generated in small quantities. A private company leases the space for the production of these isotopes. A small number of positions are used by other companies or government programs for other materials irradiation projects. For the production of plutonium-238, neptunium-237 targets would be placed in the beryllium reflector positions. The proposed target design consists of neptunium dioxide blended with aluminum powder, pressed into a target core, and clad with aluminum. The basic ATR target should be similar in appearance to, but longer than, the typical transuranic isotope production target shown in **Figure 2-7**. The ATR target length would be sized for the 1.2-meter (4-foot) active core length of ATR. Beryllium reflector position sizes range from 1.6 centimeters (0.625 inch) in diameter to 12.7 centimeters (5 inches) in diameter.

ATR is equipped with numerous safety features, including extensive plant protective systems, standby power sources, experiment interlocks, computerized surveillance, confinement systems, safety rods, and an emergency firewater injection system. ATR's six safety rods provide fast shutdown of the reactor if potentially damaging conditions develop. A sudden rise in power or coolant temperature, a sudden drop in coolant flow or pressure, or the overheating of a test sample are examples of approximately 360 conditions that would automatically drop the safety rods into the core. The firewater injection system provides emergency core cooling and flooding of the reactor vessel in the event of a loss of primary coolant. ATR is connected by a water canal to the ATR Critical Facility. The ATR Critical Facility is a low-power, full-size nuclear duplicate of ATR that is used to provide data, as needed, for experiment loadings prior to irradiation of the actual experiments in ATR.

INEEL has privatized the production of medical and industrial isotopes through contracting with a commercial entity. International Isotopes Idaho, Inc. (I<sup>4</sup>), was selected in October 1996 as the commercial business for conducting these business operations. I<sup>4</sup> specializes in producing isotopes targets for irradiation in ATR and processing and distributing commercial-grade isotopes to their customers. Prior to commercialization, INEEL's isotope production operations were limited in types and quantities. Since the start of commercial activities, I<sup>4</sup> has expanded its commercial production to become a major world supplier of several important isotopes. I<sup>4</sup> has doubled the use of ATR irradiation positions for this purpose.

The major isotopes currently produced by INEEL and I<sup>4</sup> are: iridium-192, 70 percent of the total U.S. demand; cobalt-60, 95 percent of the U.S. medical market; strontium-89, only U.S. supplier; and nickel-63, only U.S. supplier and producer of 50 percent of the world market.

Incremental investments have been identified for ATR that would make it a more versatile and capable reactor for isotope production. I<sup>4</sup> and another commercial company are in the discussion phase of investing in ATR to install an isotope shuttle (rabbit) system for the production of short-lived radioisotopes. Many of these short-lived radioisotopes are expected to be in growing demand for various cancer therapies. I<sup>4</sup> is funding an

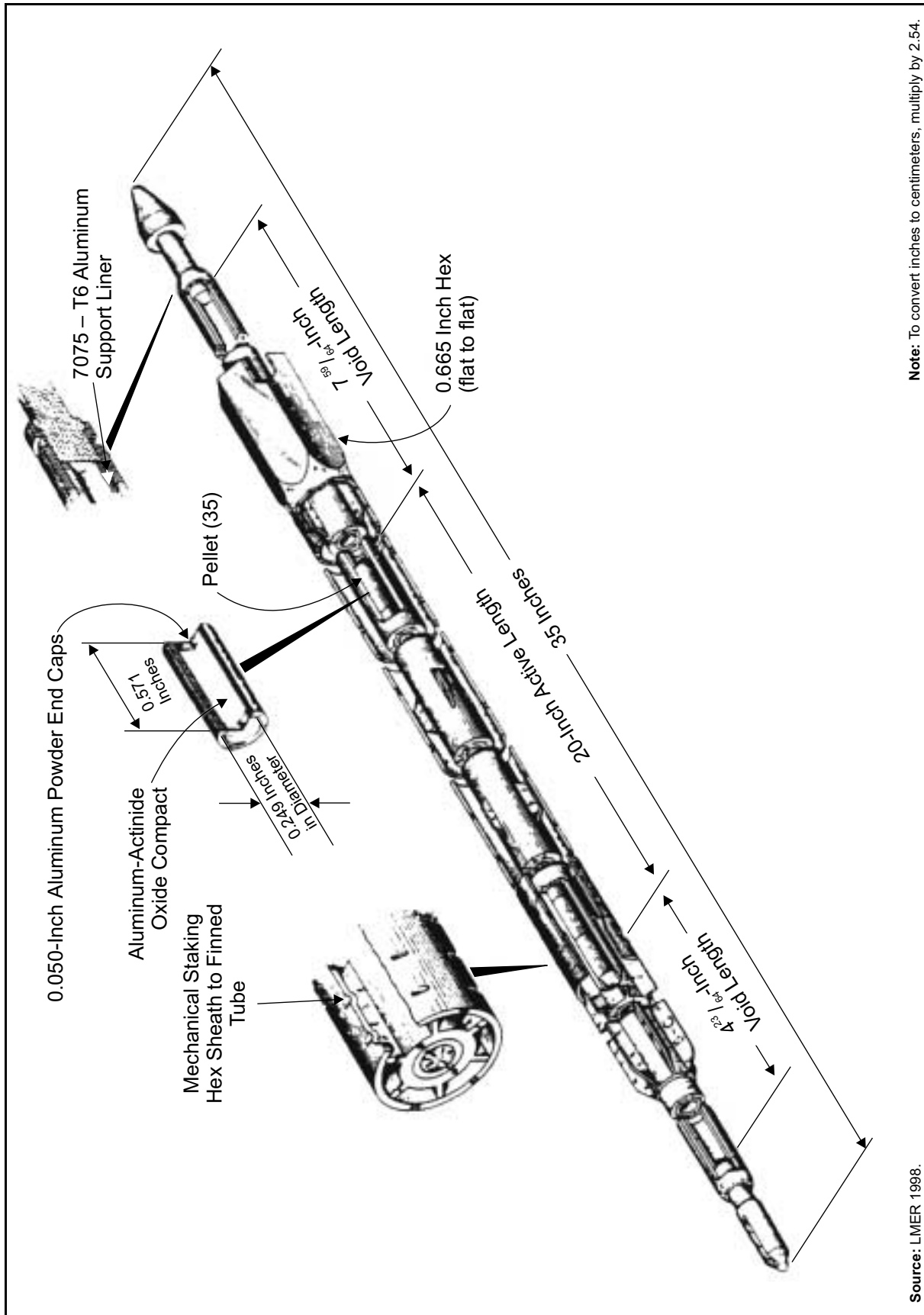


Figure 2-7 Typical Transuranic Isotope Production Target

irradiation test during the summer of 2000 that will be used as the basis for making this investment determination. I<sup>4</sup> has also committed keeping part of the rabbit system available for other users.

### **2.3.1.3 High Flux Isotope Reactor**

HFIR is a light-water-cooled and -moderated reactor operating at a thermal power level of 85 megawatts. HFIR is owned by DOE and is in the 7900 Area in the southern portion of ORR. Figure 3–1 presents a map of ORR that depicts HFIR's location.

HFIR would continue to be operated to meet the primary mission of neutron science-based research for the DOE Office of Science. In addition, medical and industrial isotope production and nuclear research and development activities would be performed on a not-to-interfere basis at the current operating level in the No Action Alternative, Alternative 1 (FFTF Restart), Alternative 3 (Construct New Accelerator[s]), Alternative 4 (Construct New Research Reactor), Alternative 5 (Permanently Deactivate FFTF), and Alternative 2 (Use Only Existing Operational Facilities) when HFIR is not providing irradiation services in support of the plutonium-238 production mission. When HFIR is supporting the plutonium-238 production mission, it would fully support its primary mission, but would support the medical and industrial isotope production and nuclear research and development activities to the extent possible within the current reactor operating levels. Consideration must be given to the need to maintain appropriate levels of neutron flux to support HFIR's primary mission. Neutron flux levels can be impacted by the placement of targets, such as neptunium-237 targets for the production of plutonium-238, in the reactor core. Under the planning assumptions for plutonium-238 production, HFIR could only produce from 1 to 2 kilograms (2.2 to 4.4 pounds) per year without impacting ongoing missions. As the program goal is to achieve a production rate of 5 kilograms (11 pounds) per year, production from HFIR would need to be augmented by the use of ATR to meet this goal. HFIR and ATR together could meet the program goal of 5 kilograms (11 pounds) per year, and could be used in combination with any one of the three processing facilities for the plutonium-238 production mission.

HFIR was originally designed as both an isotope production and a research reactor with a thermal flux of 3 to  $5 \times 10^{15}$  neutrons per square centimeter per second and a full power level of 100 megawatts-thermal ( $3.4 \times 10^8$  British thermal units per hour). It is currently operating at a maximum authorized power level of 85 megawatts-thermal ( $2.9 \times 10^8$  British thermal units per hour) to extend the useful life of the reactor. Many experiment-irradiation facilities were provided for in the original design and several others have been added. The primary mission of HFIR is neutron science research. Isotope production is done on a not-to-interfere basis.

HFIR is light-water-cooled and -moderated, beryllium-reflected, and transfers its primary coolant heat load to secondary coolant through heat exchangers for dissipation to the atmosphere by an induced-draft cooling tower. The reactor uses highly enriched uranium and aluminum-clad plate fuel. The reactor vessel itself is immersed in a pool in a poured-concrete reactor building that also houses the primary coolant pumps and heat exchangers, a spent fuel pool, and experiment areas. The control and water wing of the reactor building contains the reactor control room; relay and amplifier areas; heating and ventilating equipment; pool and fire alarm equipment; instrumentation systems; and office and support rooms. A separate electrical building adjacent to the reactor building contains switchgear, diesel generators, and associated transformers that connect the facility to offsite power. The reactor building is essentially airtight and provides dynamic confinement. A special hot exhaust system exhausts air from potentially contaminated areas of the building through two absolute filters (two charcoal beds) before being released to the atmosphere through a 76-meter (250-foot) stack. The stack serves as the exhaust point for both HFIR and REDC at ORNL.

After the reactor completed 17.2 full-power years of its 20 full-power year design life in November 1986, several measures were taken to extend the useful life of the reactor, including reducing the 100 megawatts-thermal ( $3.4 \times 10^8$  British thermal units per hour) rated power level to 85 megawatts-thermal ( $2.9 \times 10^8$  British thermal units per hour); adjusting the primary coolant temperature and pressure; conducting periodic hydrostatic tests; establishing an irradiation embrittlement surveillance program; and installing an emergency depressurization system. Subsequent life extension programs can enable HFIR to provide support during the total 35-year evaluation period for operations.

A plan view of the reactor (**Figure 2–8**) provides a cross section of the reactor vessel depicting experiment-irradiation capabilities. Experiment-irradiation facilities available include (1) the hydraulic tube facility, located in the very high flux region of the flux trap, which allows for insertion and removal of irradiation samples while the reactor is operating; (2) 30 target positions in the flux trap, which normally contain transuranium production rods but which can be used for the irradiation of other experiments (2 are instrumented target positions provided by a recent modification); (3) 6 peripheral target positions located at the outer edge of the flux trap; (4) numerous vertical irradiation facilities of various sizes located throughout the beryllium reflector; (5) 2 pneumatic tube facilities in the beryllium reflector, which allow for insertion and removal of irradiation samples while the reactor is operating for activation analysis; (6) 4 horizontal beam tubes, which originate in the beryllium reflector; and (7) 4 slant access facilities, called “engineering facilities,” located adjacent to the outer edge of the beryllium reflector. In addition, spent fuel assemblies are used for gamma irradiation in the gamma irradiation facility in the reactor pool.

The reactor core assembly is contained in a 2.44-meter (8-foot) diameter pressure vessel located in a pool of water. The top of the pressure vessel is 5.18 meters (17 feet) below the pool surface, and the reactor horizontal midplane is 8.38 meters (27.5 feet) below the pool surface. The control plate drive mechanisms are located in a subpile room beneath the pressure vessel. These features provide the necessary shielding for working above the reactor core and greatly facilitate access to the pressure vessel, core, and reflector regions.

The neutron flux within HFIR is primarily a thermal neutron flux ranging from approximately  $2 \times 10^{15}$  neutrons per square centimeter per second in the flux trap to approximately  $4 \times 10^{14}$  neutrons per square centimeter per second in the outer regions of the beryllium reflector. Specially designed neutron beam tubes provide access to neutrons that supply intense neutron beams to various specialized instruments used for neutron scattering research.

ORNL produces a variety of medical isotopes using the HFIR for irradiation and various hot cell and glovebox facilities for target fabrication and final product purification. **Table 2–2** presents a listing of HFIR-produced therapeutic radioisotopes. Key examples of the therapeutic radioisotopes currently produced in HFIR for distribution include dysprosium-166, rhenium-186, tin-117m, and tungsten-188 (parent of rhenium-188). The nine hydraulic tube positions in the central high flux region permit the insertion and removal of targets at any time during the operating cycle (22 to 24 days) and have traditionally represented a major site for the production of medical radioisotopes.

In addition to providing radioisotopes for extramural research and development and commercial applications by distribution through the DOE Isotope Production and Distribution Program, there are medical radioisotope research and development research programs at ORNL that depend on the availability of HFIR-produced radioisotopes.

The Isotopes Program at ORNL is totally funded by the DOE Office of Nuclear Energy, Science and Technology’s Isotope Production and Distribution Program. It provides enriched stable isotopes, selected radioisotopes, and related technical services for use in a wide variety of research, industrial, and especially

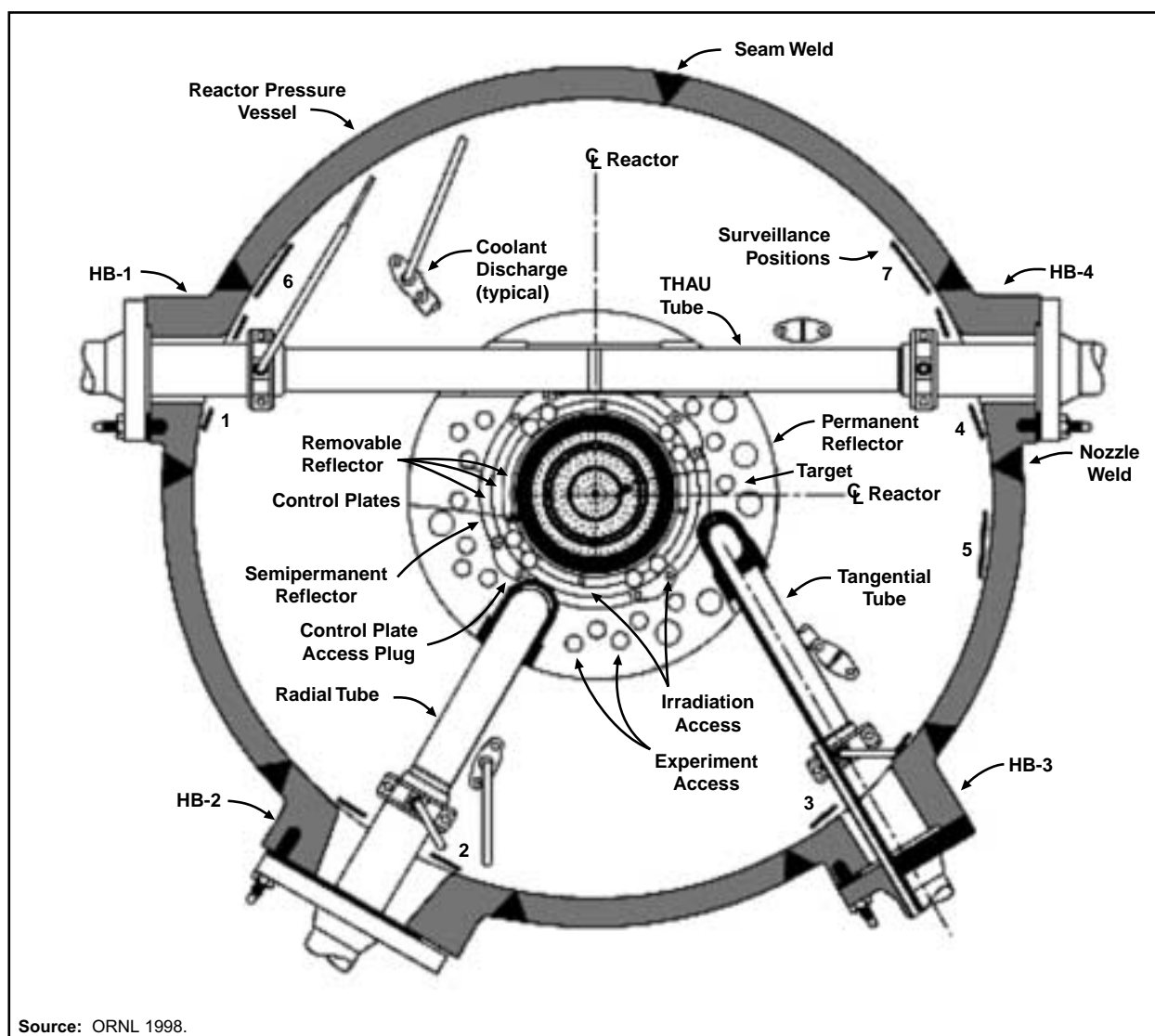


Figure 2-8 Plan View (Cross Section) of HFIR

Table 2-2 Examples of HFIR Produced Radioisotopes of Current Interest for Therapy

Radioisotope	Half-Life	Target	Comment
Palladium-103	17 days	Palladium-102	Therapy of prostatic carcinoma
Rhenium-186	3.77 days	Rhenium-185	Therapy of prostatic carcinoma
Samarium-153	1.93 days	Samarium-152	Antibodies/bone pain palliation
Tin-117m	13.6 days	Tin-116 or tin-117	Bone pain palliation
Arsenic-77 (from germanium-77)	1.62 days	Germanium-76	Bone pain palliation
Gold-199 (from platinum-199)	3.14 days	Platinum-198	Phosphorus analogue
Tungsten-188 (rhenium-188 daughter)	69 days	Tungsten-186	Bone pain/antibodies/synovectomy
Dysprosium-166 (holmium-166 daughter)	3.4 days	Dysprosium-164	Synovectomy/bone pain

medical applications. The scope of work not only includes the production of radioisotopes, but also the development of new methods and equipment to produce, recover, and purify isotope products.

#### **2.3.1.4 Commercial Light Water Reactor**

A CLWR would continue to operate and meet its primary mission requirement, providing steam for the generation of electrical power in the No Action Alternative, Alternative 1 (FFTF Restart), Alternative 3 (Construct New Accelerator[s]), Alternative 4 (Construct New Research Reactor), Alternative 5 (Permanently Deactivate FFTF), and Alternative 2 (Use Only Existing Operational Facilities) when it is not providing irradiation services in support of the plutonium-238 production mission. When the CLWR is supporting the plutonium-238 production mission, it would fully support its primary mission. The production planning assumption for the generic CLWR is 5 kilograms (11 pounds) per year of plutonium-238 or 7.5 kilograms (16.5 pounds) per 18-month operating cycle. Thus, the CLWR alone could meet the program goal of 5 kilograms (11 pounds) per year and could be used in combination with any one of the three processing facilities for the plutonium-238 production mission. The use of a CLWR for the medical and industrial isotope production mission and the DOE nuclear research and development mission was not considered practical, as discussed in Section 2.6.1.

A typical pressurized water reactor core consists of 170 to 200 fuel assemblies arranged in the reactor vessel in an approximately cylindrical pattern. Most pressurized water reactors operating in the United States are licensed to operate at thermal power levels of 2,500 to 3,500 megawatts ( $8.5 \times 10^9$  to  $1.2 \times 10^{10}$  British thermal units per hour) for net station electrical outputs of 800 to 1,200 megawatts electric ( $2.7 \times 10^9$  to  $4.1 \times 10^9$  British thermal units per hour).

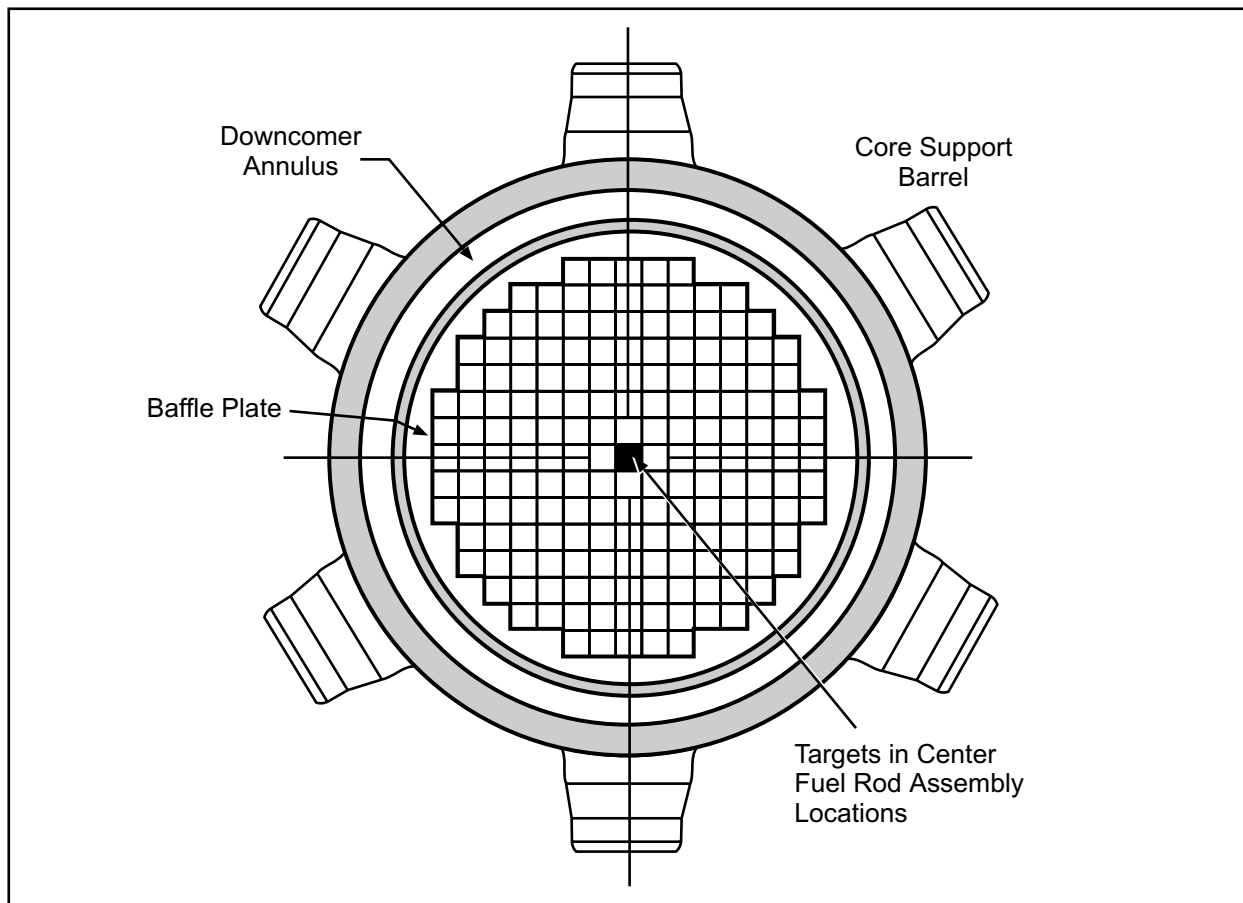
The nuclear steam supply system powered by the pressurized water reactor is generally arranged as two heat transport loops, each with two primary coolant circulating pumps and one steam generator in which the primary coolant dissipates heat generated in the reactor core to the secondary fluid in the steam generator. In addition to serving as a heat transport medium, the primary coolant also serves as a neutron moderator and reflector and as a solvent for the soluble boron used in chemical reactivity control. All nuclear steam supply system components are designed to withstand the effects of earthquakes and loss-of-coolant accidents.

The containment for a pressurized-water reactor plant consists of two structures: (1) a steel containment vessel and (2) a reinforced-concrete shield building.

The containment, including all of its penetrations, is a low-leakage steel structure designed to withstand a postulated loss-of-coolant accident and to confine a postulated release of radioactive material. It houses the reactor pressure vessel, reactor coolant piping, pressurizer, pressurizer quench tank and coolers, reactor primary coolant pumps, steam generators, core flooding tanks, and letdown coolers. Safety systems directly associated with this vessel include the containment spray system, the containment air cooling system, and the containment isolation system. An annular space is provided between the wall of the containment vessel and the shield building. Overhead clearance from the dome of the shield building is also provided.

The shield building itself is a concrete structure surrounding the containment that is designed to provide biological shielding during both normal operations and hypothetical accident conditions. The shield building enables the collection and filtration of fission product leakage from the containment following a hypothetical accident by means of its emergency ventilation system. In addition, the shield building provides environmental protection for the containment from adverse atmospheric conditions and external missiles (e.g., tornado debris).

A complete reactor core of 177 fuel assemblies, arranged in a square lattice that approximates a cylinder, is shown in **Figure 2-9**. All fuel assemblies are identical in mechanical construction and are interchangeable in any core location. The basic fuel assembly (**Figure 2-10**) is normally composed of 208 fuel rods, 16 control rod guide tubes, and one centrally-located position for instrumentation, all within a 15×15 position square



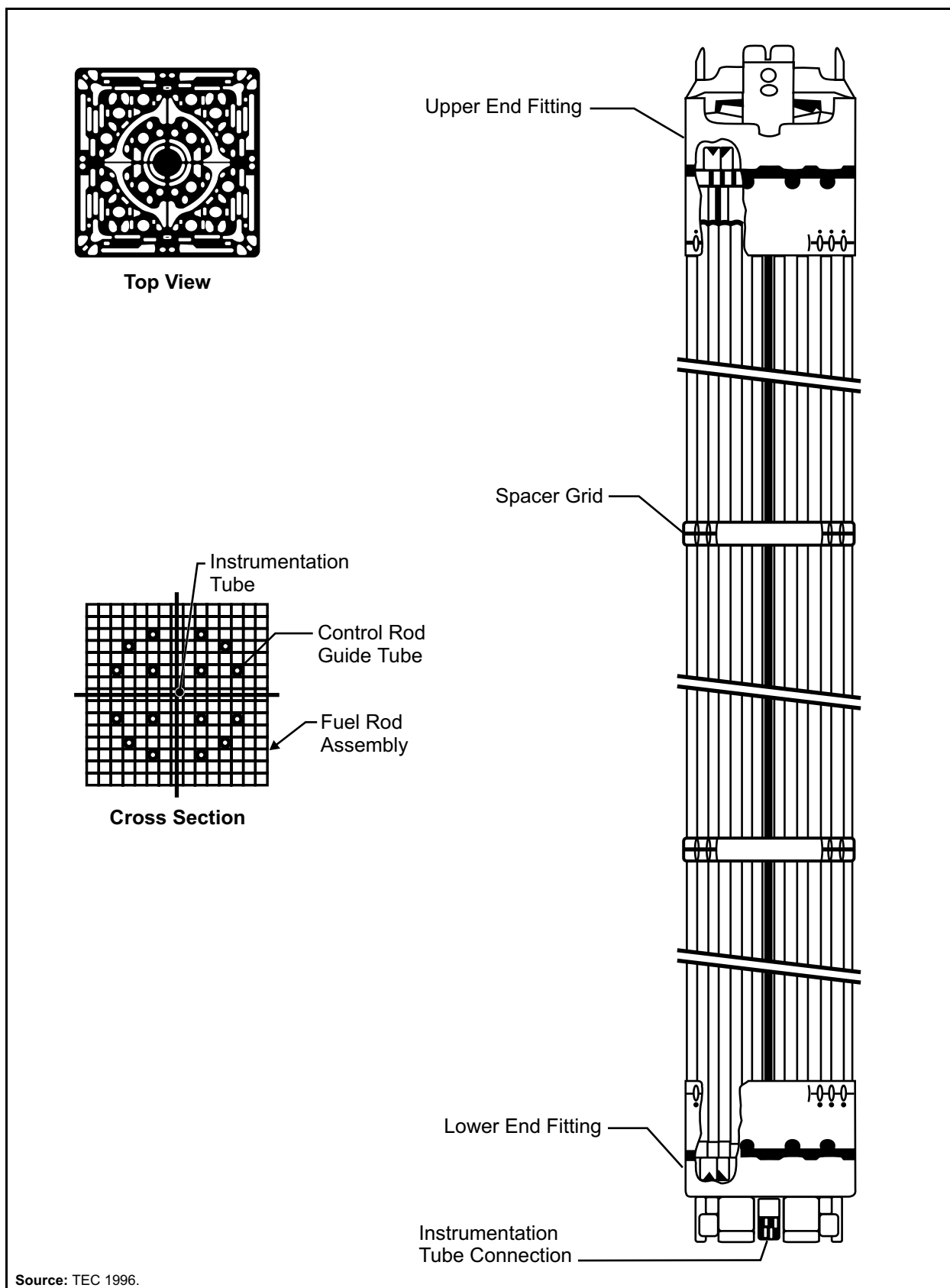
**Figure 2-9 Plan View (Cross Section) of a Generic CLWR**

array. The fuel assembly is approximately 20.3×20.3 centimeters (8×8 inches) in cross section and has an overall length of 419 centimeters (165 inches).

The substitution of target rods for fuel rod positions in the center fuel assembly would only minimally impact reactor operations. The fuel rods located in the center fuel assembly position would normally not be fresh fuel (i.e., fuel inserted within the first 18-month operating cycle in the reactor); instead, they would be in their second or third operating cycle. The normal power distribution within the core and reactor coolant flow and its distribution within the core would remain within existing technical specification limits.

#### **2.3.1.5 New Accelerator(s)**

One or two new accelerators would be constructed and operated in Alternative 3 (Construct New Accelerator[s]). Preconceptual designs have been developed for a low-energy accelerator and a high-energy accelerator for evaluation in this NI PEIS (TechSource 2000). The low-energy accelerator would support the medical and industrial isotope production missions and the nuclear research and development mission. This could effectively be accomplished with accelerator energies in the range of 30 to 70 million electron volts. The high-energy accelerator design would support the plutonium-238 production mission and the nuclear research and development mission. An accelerator with an energy level of 1,000 million electron volts is required to support the plutonium-238 and nuclear research and development missions.



**Figure 2-10 CLWR Fuel Assembly**

The preconceptual design of the high-energy accelerator presented in Appendix F focused on supporting the plutonium-238 production mission. The design of the high-energy accelerator could be refined and expanded to perform additional missions such as the production of a select set of medical and industrial radioisotopes. In addition, DOE is aware of longer-term concepts that would apply high-energy accelerators to produce “tuneable” neutrons in a subcritical assembly. Such a facility could be used to address some of the missions more familiar to reactor facilities and may hold considerable promise for future science and technology research. A facility of this nature could provide unique capabilities in areas such as the testing of many different nuclear system coolant, fuel, and materials interactions.

The accelerators would be constructed and operated at one or two existing DOE sites. The low-energy accelerator would be located on the same DOE site as the new support facility or at a DOE site with an existing support facility. The high-energy accelerator could be located at a different DOE site. Alternative 3 site selection is not evaluated as part of this NI PEIS. Because Alternative 3 is evaluated at a generic DOE site, no credit was taken for any existing support infrastructure existing at the site, and it was postulated that a new support facility would be required to support operation of the low-energy accelerator and its missions and the high-energy accelerator nuclear research and development missions if both accelerators are located on the same site. While this approach bounds the environmental impact assessment for the implementation of Alternative 3, it overstates the impacts because this NI PEIS integrates the impacts associated with constructing new support facilities and infrastructure that may be available at the existing DOE site. In the event that Alternative 3 or the low-energy accelerator alone is selected in the Record of Decision for subsequent consideration, follow-on NEPA assessments would evaluate potential locations for either both accelerators or one of the accelerators. It is highly unlikely that DOE would consider locating the new low-energy or high-energy accelerator on a DOE site that does not have an existing infrastructure capable of supporting all or most of the proposed mission requirements.

#### **2.3.1.5.1 Low-Energy Accelerator**

Three low-energy accelerator options would be available for the production of medical and industrial isotopes and to support nuclear energy research and development: (1) a high-current proton linear accelerator, (2) a multiparticle cyclotron, or (3) a proton-only cyclotron. The proton-only cyclotron would have distinct technical advantages over the other two options and is described further in the sections that follow.

The proton-only cyclotron can be either a positive proton or negative ion type and is referred to as a proton cyclotron  $H^+$  or proton cyclotron  $H^-$ . The alternative of a positive proton cyclotron would offer lower vacuum requirements and, with the latest technology, high-extraction efficiency can be achieved. But obtaining variable energy output would be complicated; extraction can be into only a single port and splitting the beam would require a complicated septum magnet. In comparison, the negative ion cyclotron would offer a continuous beam with high-current capacity using very simple high-efficiency extraction, a simple method to vary the particle energy, and the possibility of simultaneous irradiation of two different target arrays at different energies. The high-extraction efficiency would be achieved simply by passing the negatively charged beam through a thin foil that strips the electrons from the ion, creating a positive proton. The proton would be directly ejected from the machine by the existing magnetic field with high efficiency (greater than 98 percent). This feature would be important to minimize the activation of the cyclotron structure and thus reduce radiation exposure to the operational staff.

A high-beam current would be advantageous because more products could be prepared in a shorter time. In addition, a much higher specific-activity radioisotope could be prepared at the higher-beam current of the cyclotron. Specific activity is often a critical parameter in many nuclear medicine applications, including research and clinical use. The cyclotron can also continuously tune the beam energy, which would be an advantage for research. The ability to tune the energy with precision can also help achieve high-purity isotope

production by avoiding energies where impurity isotopes would be readily co-produced. These are important advantages for flexibility in research isotope production and are within the capabilities of commercially proven technology.

A new building, with a 43-meter (140-foot) by 43-meter (140-foot) footprint, would be constructed to house the cyclotron and the four beam lines. The walls of the facility would be 4.6 meters (15 feet) thick behind the target stations to minimize the neutron flux outside the building. The walls surrounding the cyclotron itself would be 3 meters (10 feet) thick. The mazes throughout the building in general would have walls 1.5 meters (5 feet) thick, so that the total thickness surrounding the cyclotron area would be 3 meters (10 feet). The beam would be diverted to the four target stations by switching magnets located in the cyclotron vault. The beam would be directed through focusing and steering magnets to the target. In the isotope production beam line (northwest cave), the targets would be installed and removed vertically from a hot cell, which would be located on the second floor directly above the target station. The power supplies for the magnets would be housed with the power supplies for the cyclotron. The mechanical equipment for cooling water would be housed in a shielded mechanical room adjacent to the cyclotron vault. Recirculating water for cooling of the targets and systems that could contain potentially radioactive material would be separated to prevent cross-contamination. These systems would be contained in mechanical equipment rooms near the respective target station. Piping would be contained in waterproof trenches with leak detection.

See Appendix F for additional details.

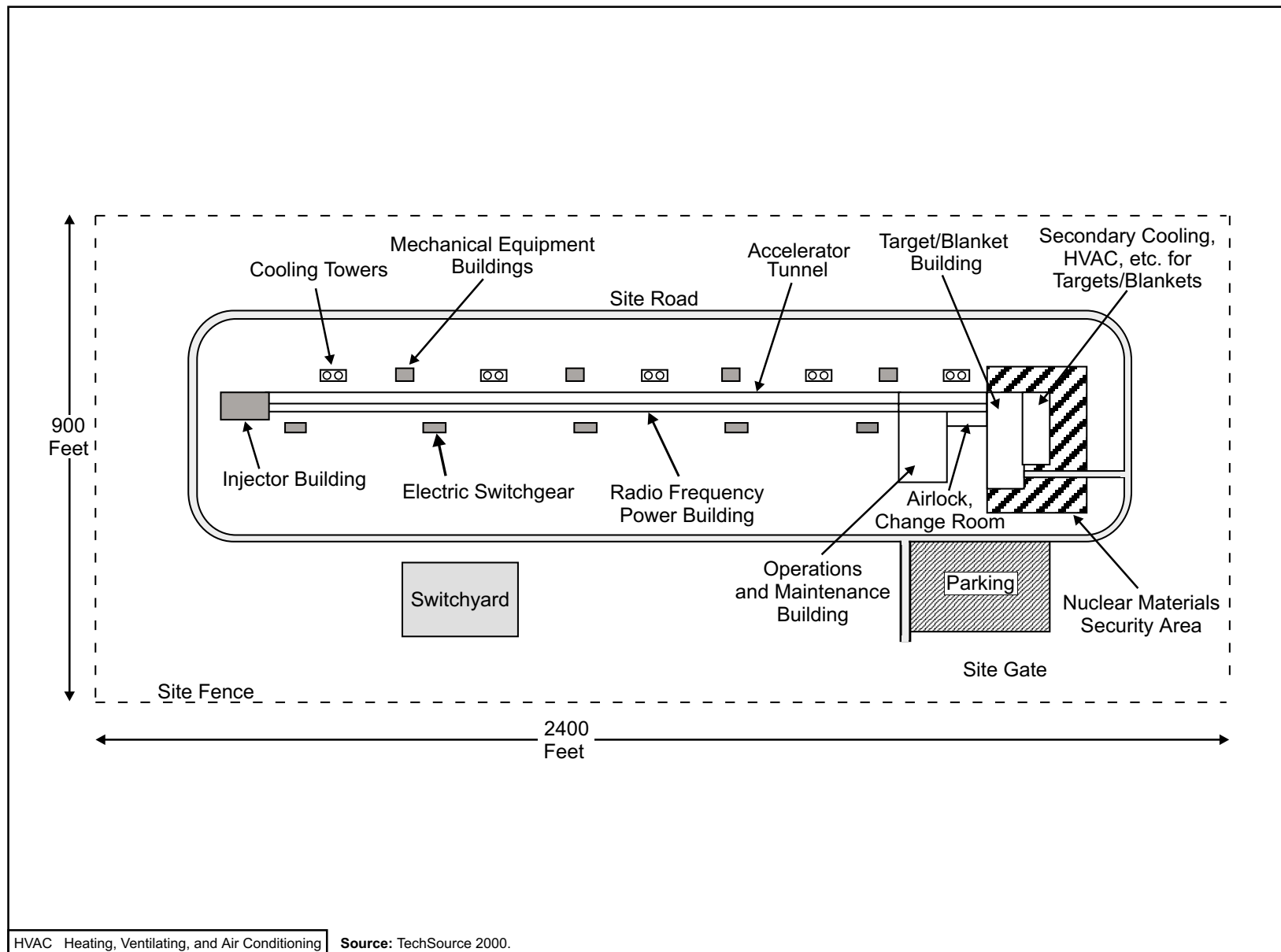
#### **2.3.1.5.2 High-Energy Accelerator**

In accelerator production of plutonium-238, an energetic beam of protons generated by a linear accelerator would be transported to a heavy metal target where spallation neutrons would be produced and moderated in a surrounding blanket. The blanket containing neptunium-237 would capture the slowed neutrons to produce plutonium-238 through the same nuclear sequence that occurs in a reactor. The accelerator would be housed in a concrete tunnel, buried below ground to provide radiation shielding for operating personnel. **Figure 2–11** presents the layout of the accelerator. A building housing radio frequency power systems and other equipment used to drive, monitor, and control the accelerator would be located above ground close to the accelerator tunnel. The target/blanket assembly would be housed inside a steel and concrete shield located within a multistory building that would contain appropriate service equipment. At the target, the small-diameter proton beam transported magnetically from the accelerator would be converted to a much larger cross section by a beam expander to reduce the power density to acceptable levels for the target cooling systems.

A source of neutrons produced by an accelerator can be used to produce plutonium-238 from neptunium-237 feedstock through the capture and decay nuclear processes. A 1,000-million-electron-volt proton beam produced by a radio frequency linear accelerator would bombard a heavy metal (uranium-238) target, with each proton producing about 40 neutrons.

A very preliminary target/blanket design has been developed for scoping purposes, based on the architecture employed in the accelerator production of tritium target/blanket design. It would use uranium-238 (cooled by heavy water [D<sub>2</sub>O]) as the neutron-production target. The target would be surrounded by a blanket of neptunium-237 in a dilute mixture of aluminum and water coolant. Enclosing the blanket would be a beryllium reflector.

To meet the plutonium-238 production goal of 5 kilograms (11 pounds) per year, the high-energy accelerator facility would conduct three 4-month production campaigns. Each campaign would be divided into 100 days of production and 21 days for recycling the production blanket. A 90 percent plant availability during the



**Figure 2-11 Accelerator Production of Plutonium Plant Layout**

scheduled operating periods is assumed. Based on operating experience at the Los Alamos Neutron Science Center Linear Accelerator, the 90 percent plant availability should be achievable.

See Appendix F for additional details. The preconceptual design of the high-energy accelerator presented in Appendix F focused on supporting the plutonium-238 production mission. The design of the high-energy accelerator could be refined and expanded to perform additional missions such as the production of a select set of medical and industrial radioisotopes. In addition, DOE is aware of longer-term concepts that would apply high-energy accelerators to produce “tunable” neutrons in a subcritical assembly. Such a facility could be used to address some of the missions more familiar to reactor facilities and may hold considerable promise for future science and technology research. A facility of this nature could provide unique capabilities in areas such as the testing of many different nuclear system coolant, fuel, and materials interactions.

#### **2.3.1.6 New Research Reactor**

A new research reactor would be constructed and operated in Alternative 4 (Construct New Research Reactor). A preconceptual design for a new research reactor was developed to meet the following DOE missions: (1) producing medical and industrial isotopes, (2) producing plutonium-238 (net annual minimum production of 5 kilograms) for use in radioisotope power systems for NASA space missions, and (3) providing irradiation services for nuclear energy research and development activities. In accordance with U.S. nuclear nonproliferation policy, a design limitation of this new research reactor is that it can only use low-enriched uranium with an enrichment of less than 20 percent uranium-235. This preconceptual design includes the basic elements of the research reactor facility, which are sufficient to support this NI PEIS, but does not include the design details (e.g., system and layout drawings, bill of materials, electrical and piping routing) commensurate with a complete preliminary reactor design.

The design of the new research reactor is based on current research reactor designs that have been approved by both the NRC and the International Atomic Energy Agency, as well as nuclear regulatory authorities of many nations. Reactor core physics calculations were performed to evaluate three different nuclear fuel designs (described in Appendix E). Based on this analysis, the desired mission for this reactor, current nuclear fuel manufacturing capabilities, and safety considerations, a TRIGA (training, research, isotopes General Atomics) production reactor fuel design was selected for the new research reactor. The principal distinguishing features of the TRIGA fuel are its proven safety performance during power pulsing and its demonstrated long-term irradiation integrity.

To concurrently produce medical and industrial isotopes along with plutonium-238 production goal of 5 kilograms (11 pounds) per year, and provide irradiation services for nuclear research and development, it was determined that a reactor core power of 50 megawatts-thermal would be necessary. The 50-megawatt-thermal power level was selected based on preliminary preconceptual designs of the reactor and targets. Subsequent to defining the baseline reactor and target designs presented in Appendix E, analyses have indicated that target design refinements and reactor design and operation refinements (e.g., increasing the operating power level to 100-megawatts-thermal) could significantly reduce the neptunium-237 target fabrication and processing requirements by increasing the neptunium-237 to plutonium-238 conversion efficiency during target irradiation by a factor of eight.

At the 50-megawatts-thermal power level, the core would require an active cooling system with forced coolant flow to maintain the fuel below its material thermal limits. The new research reactor cooling system would use a tank within a pool that is connected to primary coolant circulating pumps, heat exchangers, and an ultimate heat sink consisting of two cooling towers. The pool would be housed in a reactor building that also would enclose the pumps, heat exchangers, secondary systems, and spent nuclear fuel storage pool. The spent nuclear fuel storage pool, sized to store the reactor core’s discharged spent nuclear fuel for its entire 35-year

evaluation period, could be hydraulically connected to the reactor core pool for refueling and emergency reflooding. The ultimate heat sink cooling towers, air exhaust stack, and emergency diesel generators would be located outside the reactor building.

The fuel for the new research reactor would be based on an extension of current licensed low-enriched uranium TRIGA fuel designs for 10- to 16-megawatts-thermal reactors. The new research reactor fuel design would be identical to current low-enriched uranium TRIGA fuel for higher power cores, except the new reactor fuel would have a larger assembly configuration array (i.e., 8 by 8 versus 4 by 4) and a longer active fuel length (153.7 centimeters [60.5 inches] versus 55.88 centimeters [22.0 inches]). The larger array and length were selected to meet the plutonium-238 production requirements and to maintain high safety factors with respect to fuel thermal performance.

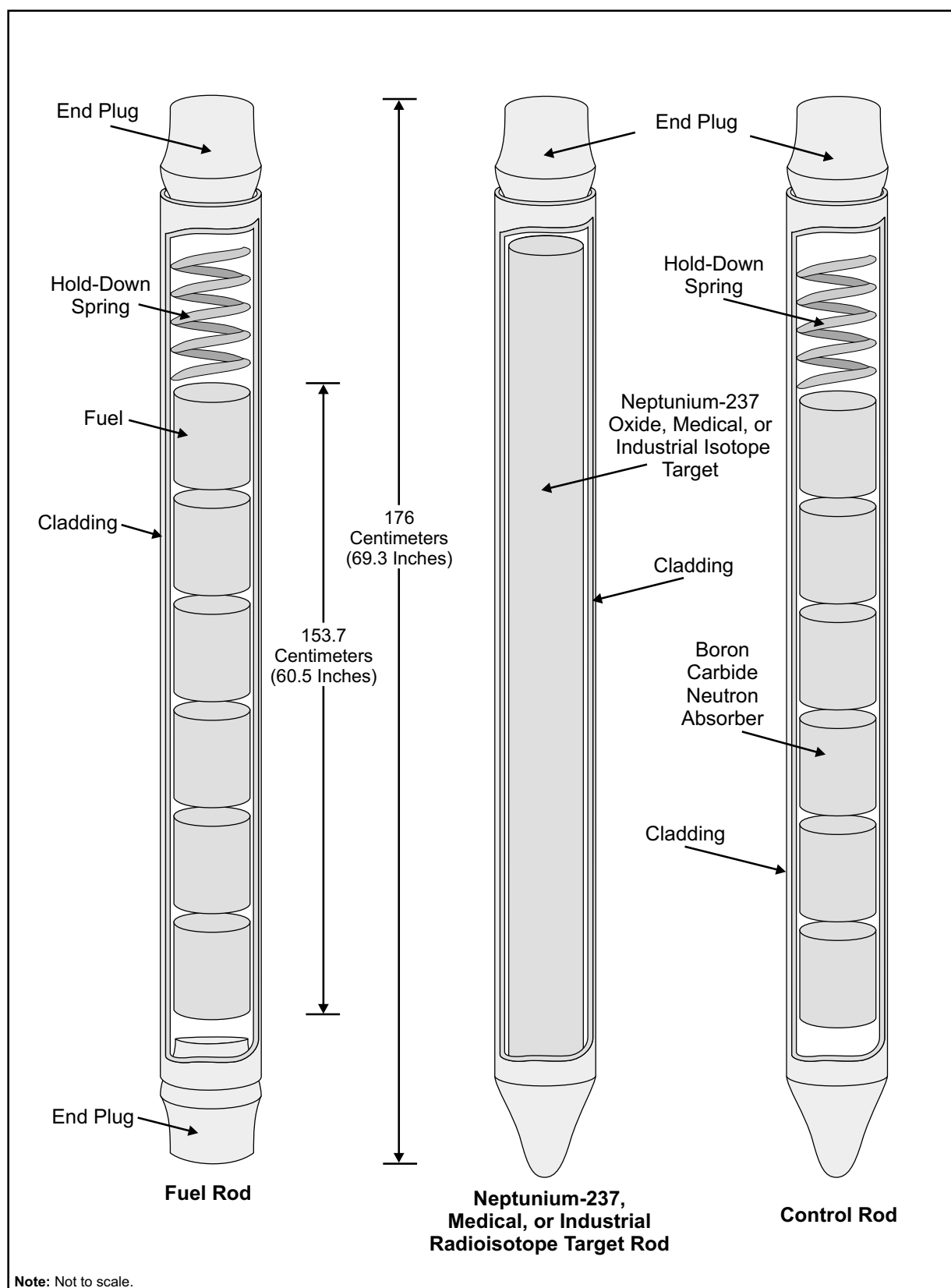
Along with the fuel rods, the core would contain a number of medical and industrial isotope and plutonium-238 production target rods. These rods would occupy positions in a fuel assembly where a fuel rod would otherwise exist. Each of these positions would have an Incoloy 800 alloy guide tube with the same dimensions as the fuel rod cladding. The target rods would be inserted into these guide tubes for their design irradiation time. In addition, some fuel rod positions in core fuel assemblies would be replaced with similar guide tubes to accommodate Incoloy 800 clad boron carbide ( $B_4C$ ) control rods. Boron carbide is a widely used, proven, and accepted neutron absorber for control rods. **Figure 2–12** presents a representative illustration of the fuel rod; the neptunium-237, medical, or industrial isotope target rod; and the control rod. **Figure 2–13** shows a cross-sectional view of each type of fuel assembly in the core. The new research reactor core design would consist of 68 fuel assemblies, each of which would be enclosed in a square aluminum shroud for structural support and coolant flow control. Key design features of the core are provided in Appendix E.

The core would include eight rabbit tubes for short irradiation time production of medical or industrial isotopes and nuclear research and development. These rabbit tubes would be located outside the fuel region of the core, but still within an area with a relatively high neutron flux. A cross-sectional view of the new research reactor core showing the layout of fuel assemblies, target rod assemblies, control rod assemblies, reflector, and rabbit tubes is presented in **Figure 2–14**.

## **Reactor Operation**

Operation of the new research reactor would be similar to other research reactors except that the core would be maintained at full power for a minimum 80 percent of the year. At the beginning of a cycle of operation, neptunium-237 and medical isotope target rod assemblies that require a long irradiation time would be inserted into their appropriate fuel assembly sleeve locations. The target rods would be mechanically attached to a cluster spider assembly similar to that used for the control rod assembly. The neptunium-237 target rod assemblies would remain in the core for the entire annual fuel cycle. These target rod assemblies would be removed from the host fuel assembly without removing the fuel assembly from the core, and then would be transferred to the spent fuel storage pool using the transfer canal.

Medical and industrial isotope target rods that require a 100-day irradiation cycle would be removed and replaced with new target rod assemblies during brief reactor shutdown periods. These target rod assemblies would be removed and transferred in a manner similar to that of the neptunium-237 target rod assemblies. Isotopes that require only a short irradiation time would be inserted into rabbit tubes for the required 10- to 25-day period. The eight rabbit tubes would be located outside the core, but inside the reflector region. The insertion and removal of irradiation targets in the rabbit tubes would have no significant effect on core reactivity and would not affect power operation.



**Figure 2-12 Representative Illustration of Fuel Rod; Neptunium-237, Medical, or Industrial Radioisotope Target Rod; and Control Rod (New Research Reactor)**

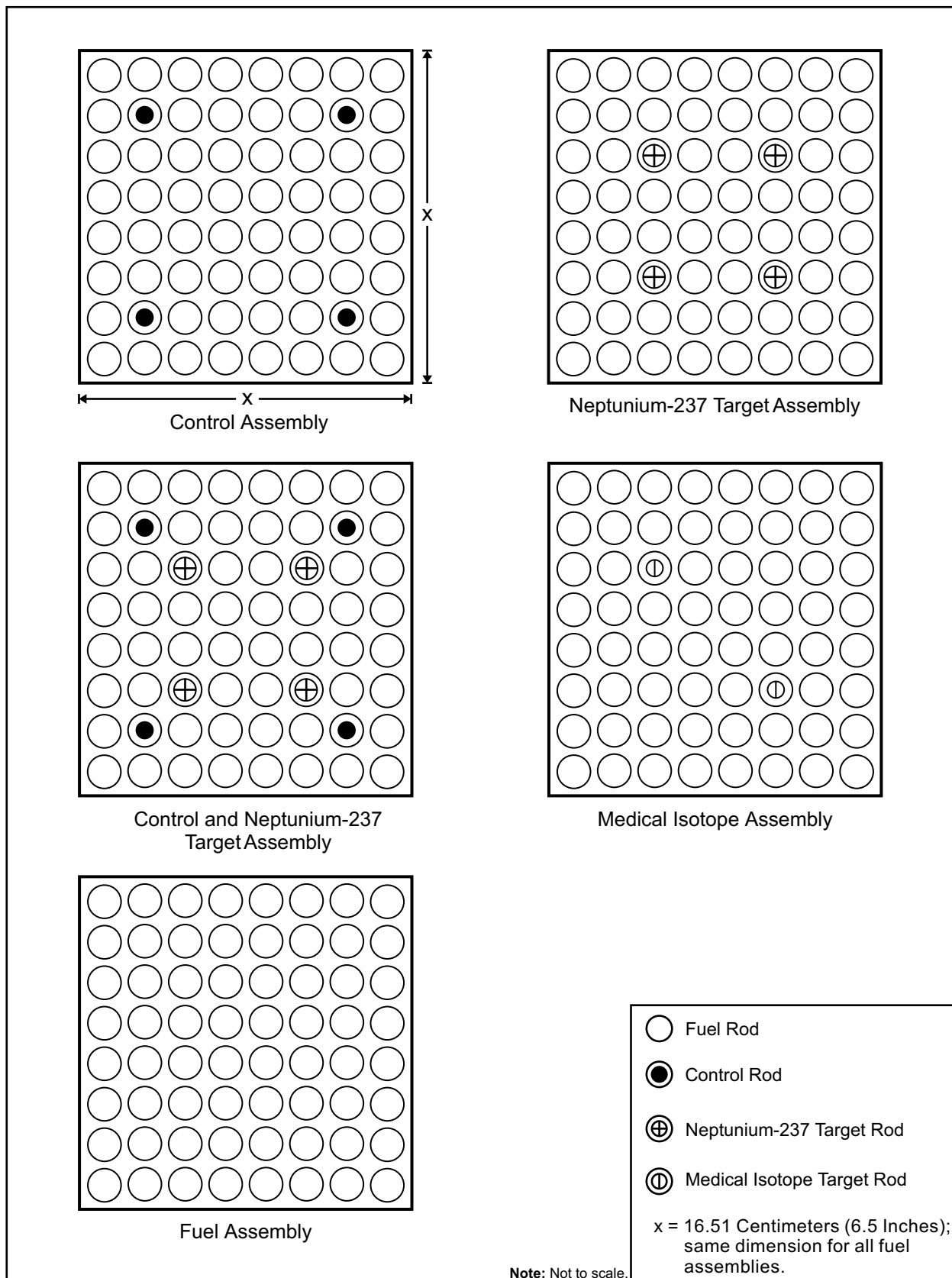
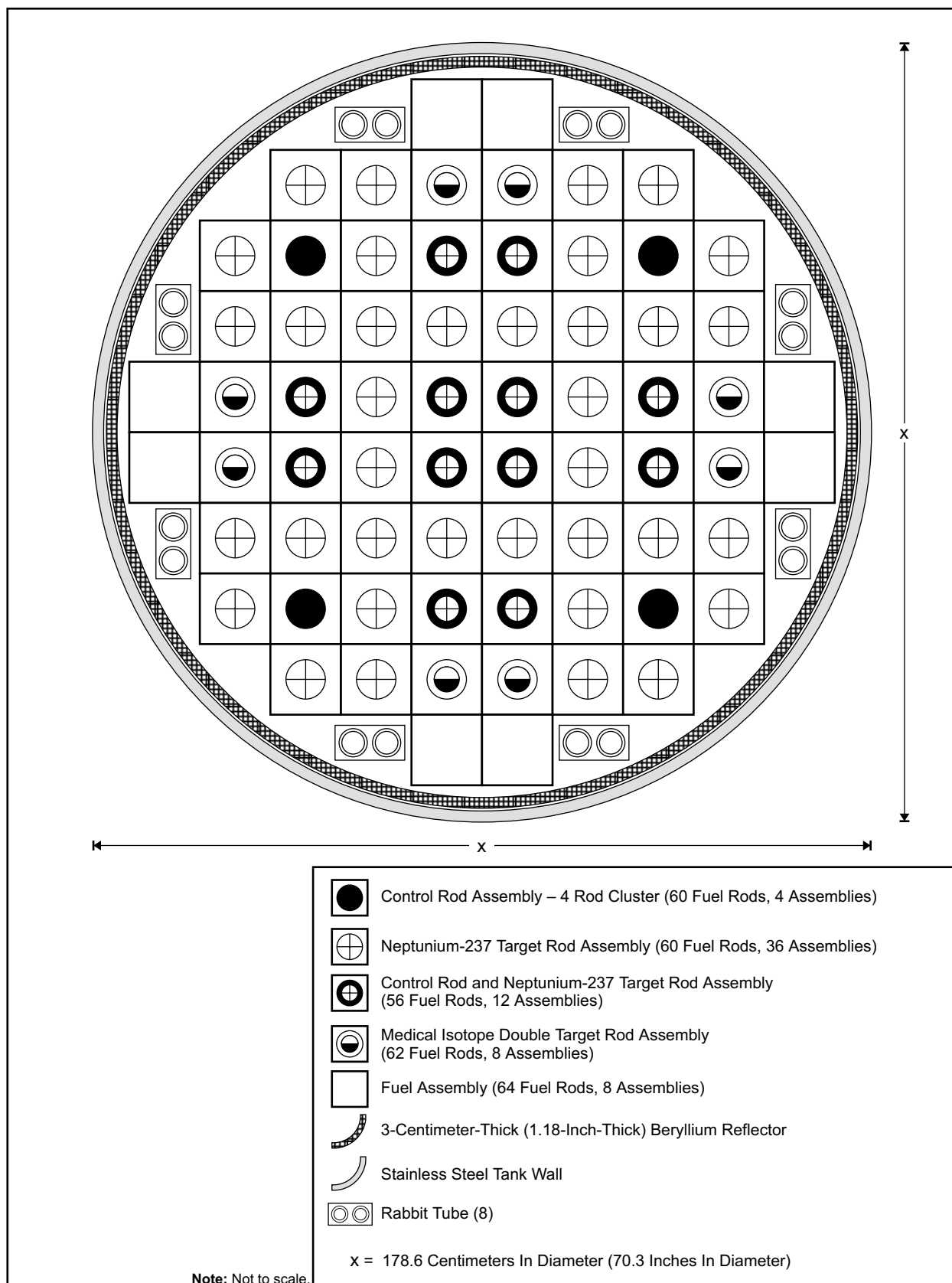


Figure 2-13 Cross Section of Fuel Assemblies in the Core (New Research Reactor)



**Figure 2-14 Cross-Section View of Research Reactor Core**

After an isotope-specific cooling time in the spent fuel pool, the medical and industrial isotope and neptunium-237 target assemblies would be transferred to a shipping cask in the spent fuel storage pool. Using the overhead crane in the spent fuel pool area, the shipping casks would be placed onto a truck in the reactor building bay adjacent to the fuel storage pool for shipment to the processing facility. New targets would be shipped from the target preparation facility into the reactor building bay by truck, transferred into the spent fuel storage pool, and subsequently moved to the reactor core pool or rabbit tube area for insertion into the core.

The plutonium-238 net annual production goal of 5 kilograms (11 pounds) was calculated to be achieved with a 300-day annual irradiation time, which corresponds to a capacity factor of approximately 80 percent. Key reactor annual resource requirements are delineated in Appendix E.

## **Reactor Construction**

Construction of the new research reactor facility was determined to require 4 years after design and licensing activities have been completed (AECL 1996; ANSTO 1999).

### **2.3.2 Target Fabrication and Postirradiation Processing Facilities**

The proposed DOE facilities that would be used for the fabrication, storage, and postirradiation processing of the targets necessary for the program mission are (1) REDC at ORNL, (2) FDPF and/or Building CPP-651 at INEEL, (3) FMEF at Hanford, (4) the Radiochemical Processing Laboratory (RPL)/Building 306-E at Hanford, or (5) a new target fabrication and processing facility at an existing DOE site that would support medical and industrial isotope production for targets irradiated in the proposed new low-energy accelerator or research reactor facilities. REDC, FDPF, and CPP-651 would support plutonium-238 production, FMEF would support both plutonium-238 and medical and industrial isotope production, while RPL/306-E facilities and the new facility would support only medical and industrial isotope production.

#### **2.3.2.1 Radiochemical Engineering Development Center**

ORNL's REDC Building 7930 is proposed for storage of neptunium-237 in one option of the No Action Alternative. It also is proposed for storage of neptunium-237, fabrication of neptunium-237 targets, and processing of irradiated neptunium-237 targets for two irradiation options in Alternative 1 (FFTF Restart), three irradiation options in Alternative 2 (Use Only Existing Operational Facilities), and for one irradiation option in Alternative 3 (Construct New Accelerator[s]) and Alternative 4 (Construct New Research Reactor). REDC's current radiochemical missions would not be impacted by the addition of the proposed storage of neptunium-237, fabrication of neptunium-237 targets, and the processing of irradiated neptunium-237 targets activities. REDC would have no role in support of Alternative 5 (Permanently Deactivate FFTF). Figure 3-1 presents a map of ORR that depicts REDC's location.

REDC is divided into four major areas: (1) a cell complex with seven cells, six shielded and one unshielded; (2) maintenance and service areas surrounding the cell complex; (3) an operating control area; and (4) an office area adjacent to, but isolated from, the operating areas. Utility services, ventilating systems, crane and manipulator systems, and liquid waste systems also are included. The proposed plutonium-238 processing and storage activities would require equipment installation in three main areas of the second floor of REDC Building 7930. A plan view of these areas is shown in **Figure 2-15**. Target fabrication would occur in the neptunium gloveboxes and extrusion press. The activities required for preparing the neptunium oxide, mixing it with aluminum for ATR or HFIR targets, and preparing the mixture for either pellet fabrication or extrusion would take place in shielded gloveboxes. The mechanical operations involved in the final target fabrication may present lesser hazards that permit them to be carried out in open boxes. Cell E would contain processing

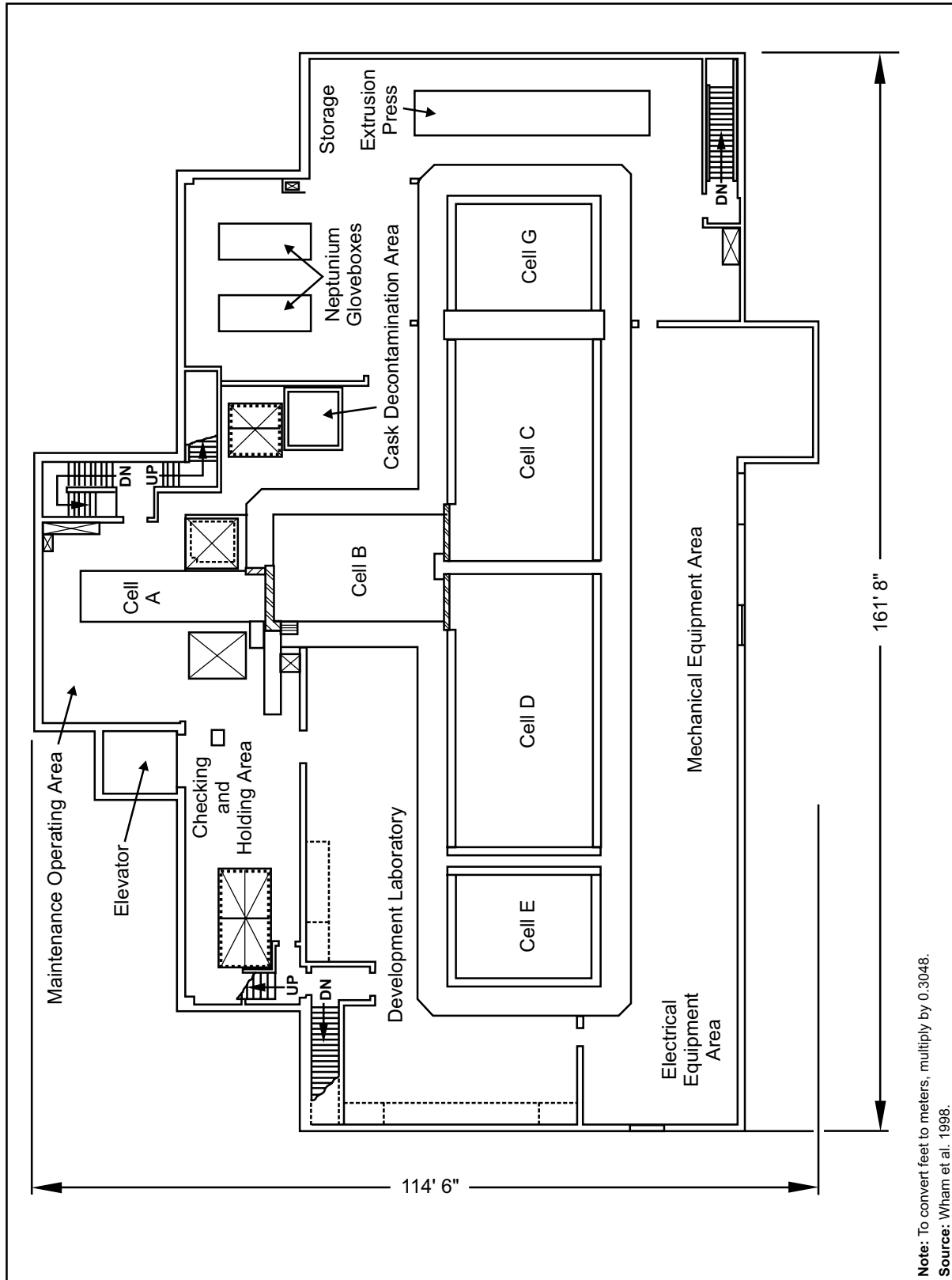


Figure 2-15 REDC Building 7930 Second Floor Plan View (Cross Section)

equipment to purify the separated plutonium-238 product, prepare the plutonium oxide, and transfer the oxide into shipping containers. Cell E would also contain vertical storage wells for dry storage of neptunium and other actinides.

Cell D activities would include receipt of irradiated targets, as well as target dissolution, chemical separation of neptunium and plutonium from fission products, and partitioning and purification of neptunium. Cell D also contain process equipment for removing transuranic elements from the aqueous waste streams and solidifying the transuranic waste.

The neptunium dioxide ( $\text{NpO}_2$ ) containers would be stored in specially designed storage vaults to provide secure, safe storage for the materials. DOE guidelines concerning safeguards and security would be followed during the times the material is stored, transported, or being processed. Detailed descriptions of the facility and the processes associated with storage, target fabrication, and postirradiation processing are provided in Appendix A.

### **2.3.2.2 Fluorinel Dissolution Process Facility**

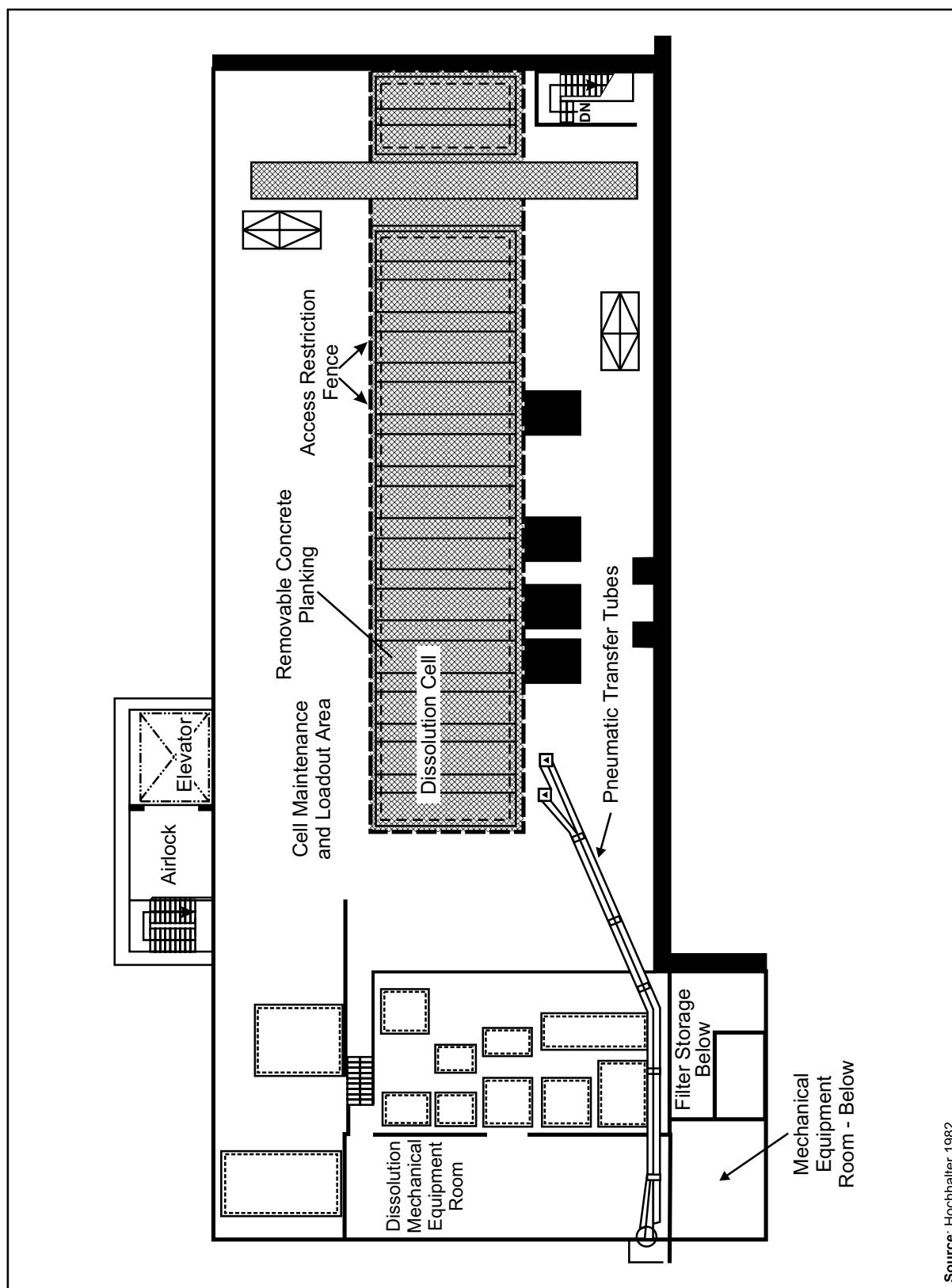
FDPF is in the Idaho Nuclear Technology and Engineering Center (INTEC), that is northeast of the Central Facilities Area at INEEL and approximately 3.2 kilometers (2 miles) southeast of ATR. FDPF is proposed for fabrication of neptunium-237 targets, and processing of irradiated neptunium-237 targets for two irradiation options in Alternative 1 (FFTF Restart), three irradiation options in Alternative 2 (Use Only Existing Operational Facilities), and for one irradiation option in Alternative 3 (Construct New Accelerator[s]) and Alternative 4 (Construct New Research Reactor). Figure 3–3 presents a map of INEEL that depicts FDPF's location.

FDPF has no current mission. Historically, INTEC reprocessed spent nuclear fuel from U.S. Government reactors to recover reusable highly enriched uranium. After DOE announced in April 1992 that it would no longer reprocess spent fuel, reprocessing operations at INTEC ended. Two buildings at INTEC are candidate storage and processing sites for plutonium-238 production: Building CPP–651, the Unirradiated Fuel Storage Facility, and Building CPP–666, FDPF. Building CPP–651 was originally designed for the storage of special nuclear materials to support Defense Programs and is quite flexible in terms of the size and shape of special nuclear materials that it can receive and store. The 100 storage positions in the vault use the existing structural barriers of Building CPP–651 (earth and concrete) and provide supplemental security protection via their in-ground concrete storage silo design. Each storage position houses a rack that holds seven highly enriched uranium product cans. Racks are raised and lowered in their storage positions via an overhead 1-ton hoist.

Building CPP–666 is divided into two parts, the Fuel Storage Facility and FDPF. The Fuel Storage Facility consists of receiving and unloading areas, a fuel unloading pool, and six storage pools for storing nuclear fuel.

FDPF was designed and built to process Navy fuel via three dissolver trains. When fuel reprocessing was discontinued, uranium and hazardous materials were flushed from FDPF, and the facility is currently under consideration for new missions. FDPF consists of a large hot cell and supporting areas with a total area of approximately 3,700 square meters (40,000 square feet). The facility is divided into five levels that are identified by their elevation relative to ground level (Hochhalter 1982). A floor plan of the plus 28-foot level, the proposed location for the neptunium glovebox train and the target fabrication glovebox, is shown in **Figure 2–16**.

The chemical separation would take place in the FDPF cell using small centrifugal contactors installed for that purpose. Storage of neptunium-237 would be performed in Building CPP–651, which is located within



Source: Hochhalter 1982.

**Figure 2-16 Fluorinel Dissolution Process Facility Plus 28-Foot Level**

100 meters (328 feet) of FDPF. There are 100 in-ground concrete-shielded storage well positions in this vault. Each storage well contains a rack that can be modified to house cans of neptunium-237.

The neptunium dioxide containers would be stored in specially designed storage vaults to provide secure, safe storage for the materials. DOE guidelines concerning safeguards and security will be followed during the times the material is stored, transported, or being processed. Detailed descriptions of the facility and the processes associated with storage, target fabrication, and postirradiation processing are provided in Appendix A.

The FDPF portion of INTEC includes a hot cell about 6.1 meters (20 feet) wide, 30.5 meters (100 feet) long, and 15.2 meters (50 feet) deep that is shielded by 1.8-meter-thick (6-foot-thick) concrete walls, as shown in **Figure 2–17**. The cell was designed to process Navy spent nuclear fuel via three dissolver trains, each of which consists of a 1,700-liter (450-gallon) Hastelloy C-4 dissolver and a 6,500-liter (1,720-gallon) Hastelloy C-4 complexer vessel in series. Each train is connected to a common 8,000-liter (2,110-gallon) stainless steel product transfer vessel that was used for accountability sampling prior to transferring the adjusted fuel dissolution product for solvent extraction separations. If the targets were dissolved in a continuous process, a small, 12.5-liter (3.3-gallon) dissolver would be skid-mounted on the grate at the level of the dissolver lids, and the dissolvers would be used for collecting the dissolution product of irradiated neptunium-237 targets. If a batch dissolution process were used, a skid-mounted, small 200-liter (53-gallon) dissolver system designed for the small target dissolution throughput rate could be skid-mounted on the grate at the level of the dissolver lids for batch processing. Three complexer vessels in the cell could be used for waste or rework solution collection, or for the collection of condensate if a waste evaporator were employed. The head-end dissolution system is supported by remote manipulators (overhead and master/slave), as well as an underwater fuel transfer system and crane for target transfer and waste loadout. The dissolver offgas system scrubs potentially hazardous chemicals and filters radioactive particles from the offgases of the process vessels before releasing them into the heating, ventilating, and air conditioning exhaust system. The chemical separation would take place in the FDPF cell using small centrifugal contactors installed for that purpose. The storage of neptunium-237 would be performed in either FDPF or in a secure vault facility, Building CPP–651, which is located within 100 meters (328 feet) of FDPF. There are 100 in-ground concrete-shielded storage well positions in this vault. Each storage well contains a rack that can be modified to house cans of neptunium-237.

Detailed descriptions of the facility and the processes associated with storage, target fabrication, and postirradiation processing are provided in Appendix A.

### **2.3.2.3 Fuels and Materials Examination Facility**

Use of Hanford's FMEF is proposed for storage of neptunium-237 in one option of the No Action Alternative. It also is proposed for storage of neptunium-237, fabrication of neptunium-237 targets, and processing of irradiated neptunium-237 targets for two irradiation options in Alternative 1 (FFTF Restart), three irradiation options in Alternative 2 (Use Only Existing Operational Facilities), and for one irradiation option in Alternative 3 (Construct New Accelerator[s]) and Alternative 4 (Construct New Research Reactor). In addition to the support of the plutonium-238 production mission activities in Alternative 1, FMEF would also support medical and industrial production mission and nuclear research and development mission activities at the Hanford Site. FMEF would have no role in supporting Alternative 5 (Permanently Deactivate FFTF). FMEF is adjacent to the west of FFTF in the 400 Area of Hanford. Figure 3–6 presents a map of Hanford that depicts FMEF's location.

FMEF was built during the late 1970s and early 1980s as a major addition to the breeder reactor technology development program on the Hanford Site. Although it has never been used, the facility was constructed to

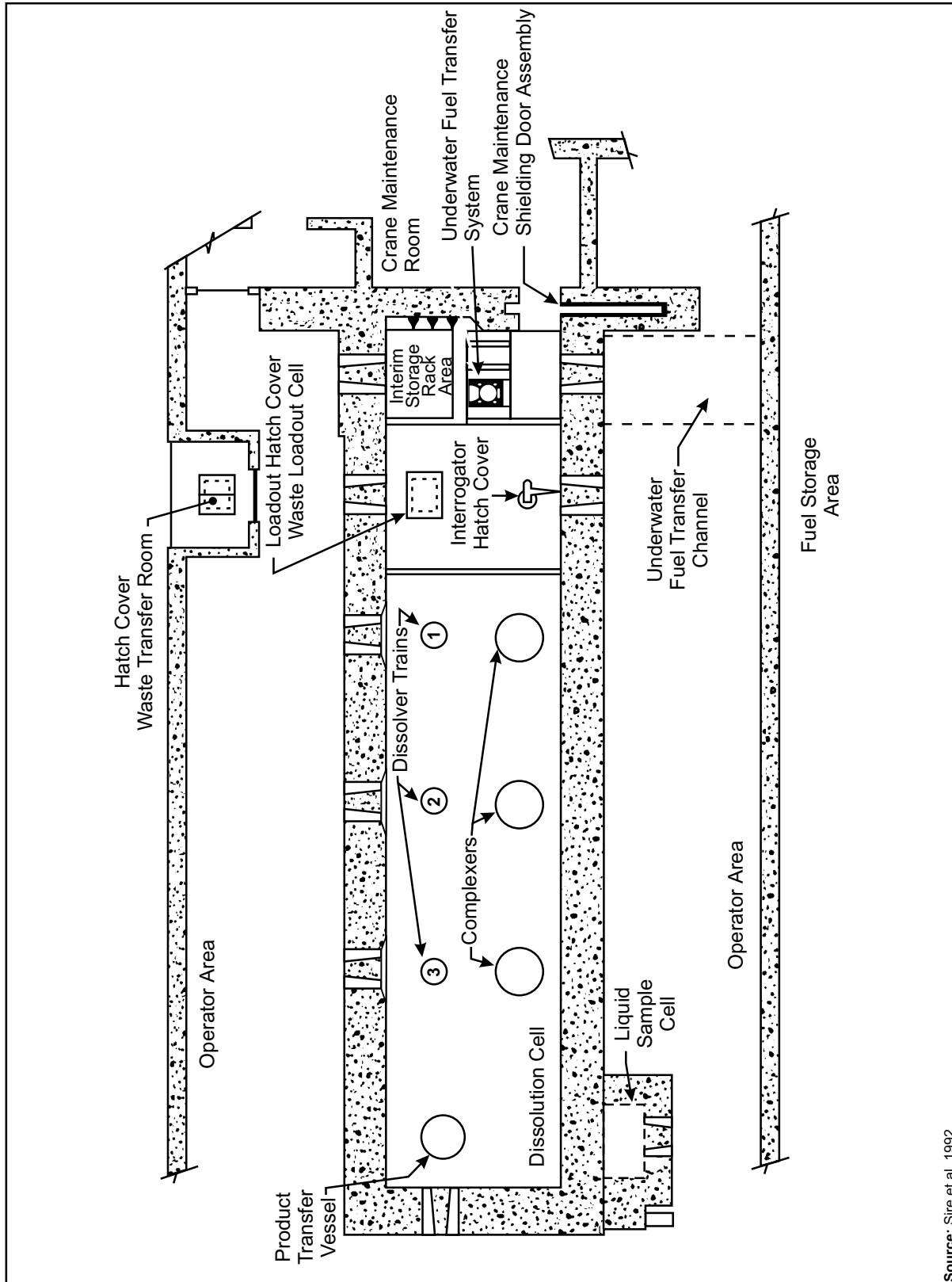


Figure 2-17 Plan View of FDPF Cell

Source: Sire et al. 1992.

perform fuel fabrication, and development and postirradiation examination of breeder reactor fuels (DOE 1995b).

FMEF is currently being maintained in a condition suitable for a future mission. In 1998, FMEF was placed into a partial layup condition in order to reduce the cost of maintaining the facility. Many systems were shut down and most hazardous materials were removed from the building. However, FMEF is considered clean and uncontaminated because no nuclear materials have been introduced (Hoyt et al. 1999). Some critical systems remain in operation, e.g., the fire detection and protection systems. In order to avoid freezing of the fire protection water systems, limited heating and ventilating remain available. For example, the heating, ventilating, and air conditioning system has been modified to simplify its operation by blocking automatic dampers in appropriate configurations. Also, although the chillers have been laid up, including removal of the refrigerant, the chilled water system (containing an ethylene glycol-water mixture) remains available to help distribute heat within the building. Electrical power and lighting remain available, and the freight elevator remains in service to support routine facility walkdowns and any required maintenance. FFTF staff conducts surveillance and maintenance of FMEF.

FMEF consists of a 30-meter-high (98-foot-high) Process Building, which has an attached Mechanical Equipment Wing on the west side and an Entry Wing on the south (front) side. The Mechanical Equipment Wing houses utility and support equipment, including water treatment equipment, air compressors, and a portion of the air conditioning equipment.

The Entry Wing contains space for reactor fuel assembly (recently used as a training facility in support of the Hanford Site cleanup mission), lunchroom and change rooms, and heating and air conditioning equipment associated with the Entry Wing. Personnel access into the Process Building is provided via a Security Guard Station and automated personnel access control portals located on the first floor of the entry wing. Office space and administrative support areas are also housed on the second floor of the Entry Wing (DOE 1995b).

The Process Building is approximately 53.3 meters (175 feet) wide by 82.3 meters (270 feet) long, and extends from around 10.7 meters (35 feet) below grade to 29.7 meters (98 feet) above grade. Total potential operating space is approximately 17,400 square meters (188,000 square feet). The Process Building contains several large interconnected hot cells and many smaller connected hot cells. Major cranes are available, but some cranes, windows, and manipulators were not installed because construction of FMEF was halted prior to completing work on the hot cell complex (Hoyt et al. 1999). Nevertheless, the building is divided into six operating floors or levels, which are identified in the following manner by their elevation relative to ground level and their primary function:

- The topmost floor at the 21.3-meter (70-foot) elevation is called the Secure Automated Fabrication Level. This level contains the Secure Automated Fabrication Line, automated fabrication equipment originally designed to produce reactor fuel.
- The lower Fuel Fabrication Level at the 12.9-meter (42-1/2-foot) elevation consists of two separate operating areas—one designated at the Low Gamma Test Pin Fabrication and Development Area, and the other as the Unit Process Cell. This level provides approximately 472 square meters (5,100 square feet) of potential operating space around the Unit Process Cell. This cell area is highly shielded by thick concrete walls and was intended for the future development of remote fabrication and maintenance equipment, or for the production of high gamma test pins. However, this cell area is not equipped at this time.
- The lower Chemistry Level at the 3.2-meter (21-1/4-foot) elevation surrounds the upper portions of the Nondestructive Examination Cell and the Decontamination Cell, which extend upward from the

floor below. This level was designed to contain equipment to perform the chemical analyses of fuel material necessary to support fuel fabrication work. Much of the work planned in this area was to be performed in gloveboxes to reduce personnel radiation exposures. Also, located on this level, is an automated system potentially available for handling and storing the special nuclear material, such as the feed material for the fuel fabrication processes. The area encompasses approximately 787 square meters (8,500 square feet) of potential operating space.

- The Entry Level at ground level is the main operating floor of the Nondestructive Examination Cell, which also extends into the floors above and below. The Nondestructive Examination Cell was designed to contain remotely-operated equipment for the nondestructive examination of irradiation fuel assemblies and pins. Maintenance and decontamination of equipment was to be performed in the adjacent Decontamination Cell. The Entry Level also contains computer and operations control rooms, and inert gas systems and building air exhaust equipment. The Shipping and Receiving Area, which comprises approximately 500 square meters (5,400 square feet) of operating floor space, is located at the extreme east end of the Process Building on the Entry Level. This area includes a liquid waste loadout station, a solid waste storage area, a truck lock, and a large high bay material handling area.
- The Equipment Level at the minus 5.3-meter (17-1/2-foot) elevation was designed to contain a variety of support equipment, including two separate electrical switchgear rooms, emergency air compressors, heating and ventilating system air supply equipment, Nondestructive Examination Cell inert atmosphere equipment, emergency batteries, analytical chemistry cell exhaust equipment, and building air filtering system components. Also included is the vacuum equipment associated with the vacuum and air sample vacuum systems.
- The DE Cell Level at the minus 10.7-meter (35-foot) elevation (see **Figure 2–18**), contains cells originally intended for destructive examination of fuels and materials samples. These cells are arranged in two parallel rows along a horizontal transfer corridor that was to be used to transfer equipment between individual cells. The DE Cell area is heavily shielded, and work in the cells was planned to be performed using remotely-operated equipment. The Entry Tunnel extends from below the Shipping and Receiving Area floor (on the Entry Level) to the DE Cell Level (10.8 meters or 35-1/2 feet total height). The Entry Tunnel was designed to house a 75-ton rail-mounted transporter intended to transfer casks between the Shipping and Receiving hatch and the Decontamination Cell and Nondestructive Examination Cell Floor penetrations. The transporter rails are located roughly halfway up the tunnel (5-meter or 16-1/6-foot elevation).

The use of FMEF for neptunium-237 target material storage, target fabrication, and postirradiation processing would require the construction of a new 76-meter (250-foot) stack. The neptunium dioxide (NpO<sub>2</sub>) containers will be stored in specially designed storage vaults to provide secure, safe storage for the materials. DOE guidelines concerning safeguards and security will be followed during the times the material is stored, transported, or being processed. Detailed descriptions of the facility and the processes associated with storage, neptunium-237 target fabrication, and postirradiation processing in support of plutonium-238 production are provided in Appendix A.

#### **2.3.2.4 Radiochemical Processing Laboratory/306–E**

Two Hanford 300 Area facilities are proposed to support medical and industrial isotope target fabrication and postirradiation: RPL and Building 306–E. The facilities support the four irradiation options in Alternative 1 (FFTF Restart) that are not supported by FMEF. RPL/306–E would be used to support medical and industrial isotope production and nuclear research and development activities. These activities would not impact current

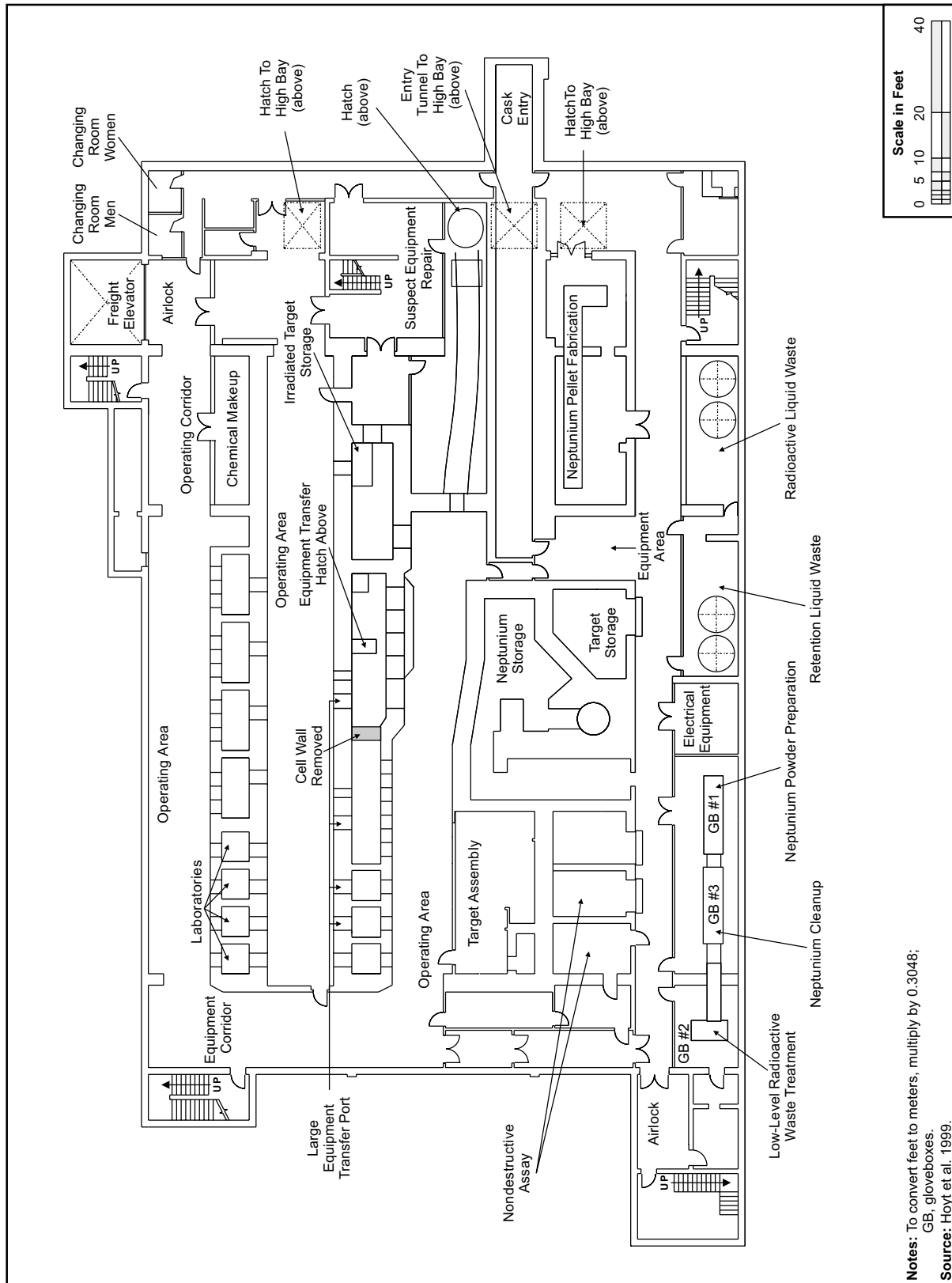


Figure 2-18 FMEF Layout, Minus 35-Foot Level

missions at the facilities. RPL/306–E have no role in support of the No Action Alternative, Alternative 2 (Use Only Existing Operational Facilities), Alternative 3 (Construct New Accelerator[s]), Alternative 4 (Construct New Research Reactor), and Alternative 5 (Permanently Deactivate FFTF). Figure 3–6 presents a map of Hanford that depicts the locations of RPL/306–E.

#### **2.3.2.4.1 Development Fabrication Test Laboratory (Building 306–E)**

Building 306–E was constructed in 1956 as part of the nuclear material production program at Hanford, and was used to develop the col-extrusion process for N-Reactor fuel. Major upgrades and renovations were completed in the late 1960s and early 1970s to support the civilian reactor development program (Liquid Metal Reactor Program–FFTF). The building has 4,273 square meters (46,000 square feet) of floor space, with a 36.5-meter by 61-meter by 6.4-meter high (120-foot by 200-foot by 21-foot-high) bay containing three 10-ton, one 5-ton, and one 1-1/2-ton cranes. The facility has electron beam a laser welding, certified nondestructive testing, a 3.7-meter by 3.7-meter (12-foot by 12-foot) vertical assembly and test station with 24.4-meter (80-foot) hook height, a machine shop, and an instrument development laboratory. A description of the spaces is provided below; a view of the floor plan is provided in **Figure 2–19**

<u>Function</u>	<u>Area (square feet)</u>
Offices	4,298
Laboratories	25,003
Shops	2,358
Conference	511
Common	14,133
Total	46,303

The building is serviced by three 1,416 cubic meter (50,000 cubic feet) per minute supply units complete with filters, steam coils and spray chambers. Two of the units have refrigeration coils for summer time cooling. Two ceiling mounted 1,012-cubic-meter-per-minute (35,750-cubic-feet-per-minute) recirculation fans with freon compressors provide additional cooling and air movement. Fume hoods have individual exhaust fans. Chemical and acid tanks exhaust through two 340-cubic meter-per-minute (12,000-cubic-feet-per-minute) fume scrubbers to a 12.2-meter-high, 7.6-centimeter-diameter (40-foot-high, 3-inch-diameter) stainless steel exhaust stack. Equipment exhaust collects through a grid that leads to two 566-cubic-meter-per-minute (20,000-cubic-feet-per-minute) exhaust fans. Plastic hoods and duct work are provided for highly corrosive service.

Major equipment includes three industrial x-ray machines, a 6-kilowatt Hamilton Standard electron beam welder, five open face hoods, two inert gas welding chambers and one electrolytic cutoff saw.

Utilities include hot and cold water, deionized water, propane, helium, compressed air, argon, steam and sanitary of process sewers as well as a special acid drain and neutralizing tank. Normal power is provided by a 1500-kilovolts ampere transformer with 150 kilovolts ampere backup power from an adjoining building, and a 30 kilovolts ampere emergency transformer. The building is protected by redundant emergency alarm systems, fire gongs, and an evacuation siren.

#### **2.3.2.4.2 Radiochemical Processing Laboratory**

The research and development activities of the Radiochemical Processing Group are conducted at RPL in the 300 Area of Hanford. RPL consists of a central area that contains general purpose laboratories designed for low-level radioactive work, a front wing that contains office space and shops, and two annexes that provide

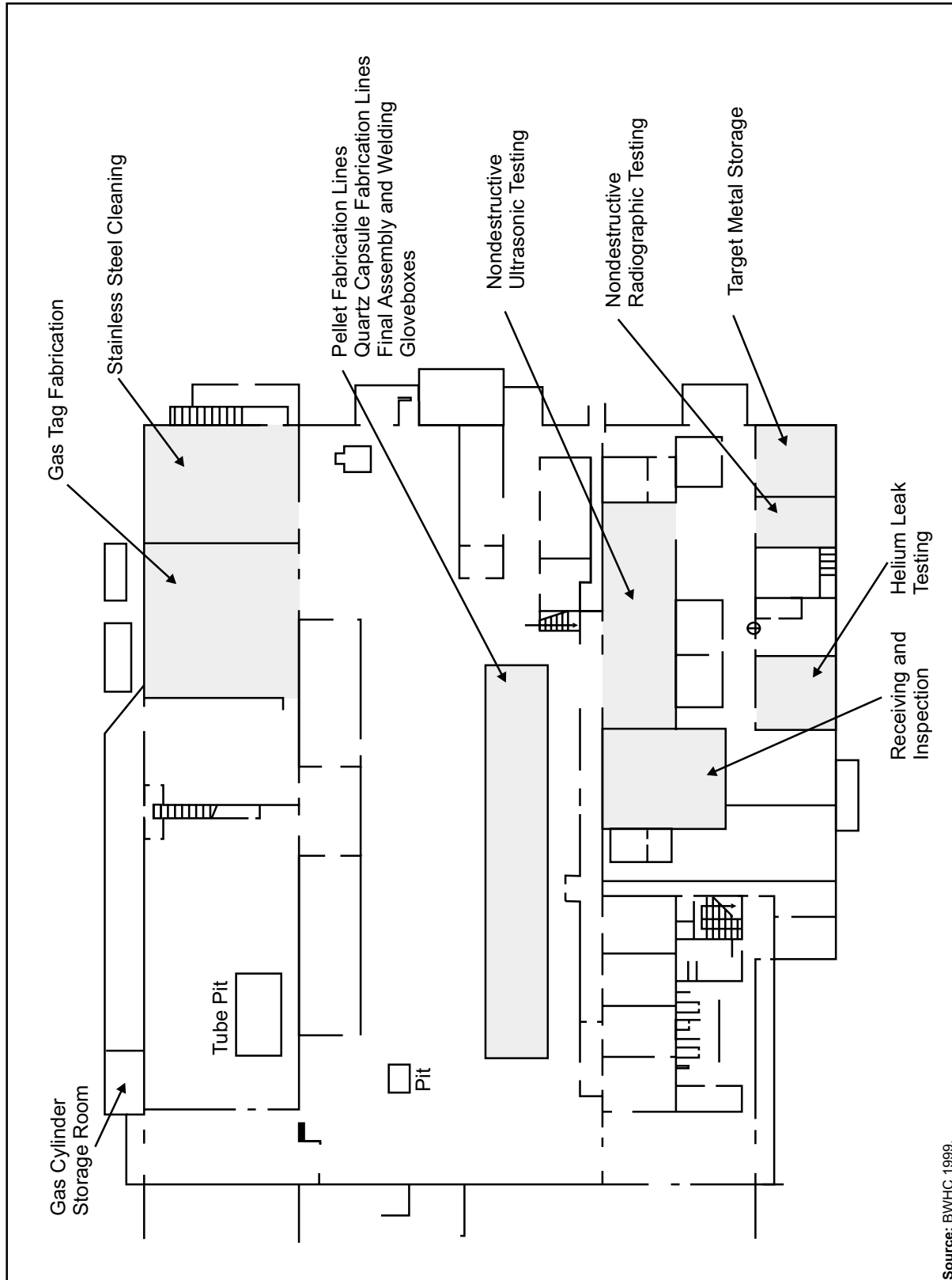


Figure 2-19 Building 306-E Floor Plan

Source: BWHC 1999.

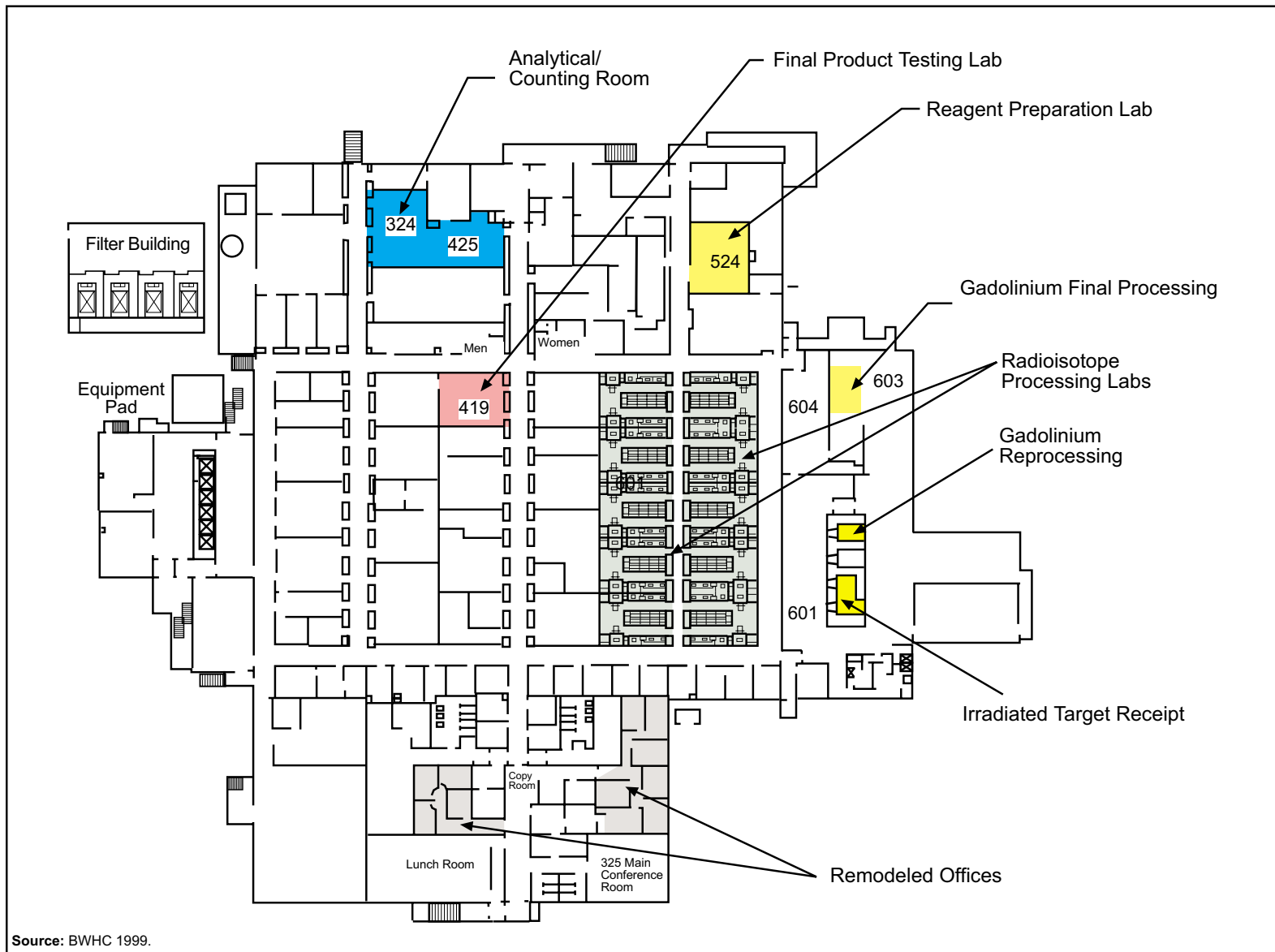
shielded enclosures with remote manipulators for high-level radiochemical work. The facility also contains laboratories and specialized facilities designed for work with nonradioactive materials, microgram-to-kilogram quantities of fissionable materials, and up to megacurie quantities of radionuclides. RPL would be the primary site for fabricating the radioactive targets (i.e., targets containing radium-226 or recycled materials from previous irradiations).

Total space within RPL is 13,350 square meters (143,700 square feet), of which 4,140 square meters (44,500 square feet) are occupied by general chemistry laboratories. The floor plans for the first floor and the basement of RPL are shown in **Figures 2–20** and **2–21**. A recent space utilization survey of RPL indicated that 649 square meters (6,950 square feet), representing 15.6 percent of the facility, are presently unoccupied. All of the occupied and nearly all of the unoccupied laboratories are functional and are fully equipped with standard utilities. Several of the laboratories, especially those used for radioanalytical work, have been renovated during the past few years. Upgrading and modernization of the equipment within the chemistry laboratories has been given a high priority during the past 2 years. During the space utilization survey at RPL, an assessment was made of the number of fume hoods and shielded gloveboxes (including several small hot cells) that are available in the chemistry laboratories for additional programmatic work. Of the 79 functional fume hoods and 23 shielded gloveboxes, 50 fume hoods and 15 gloveboxes are available for additional work.

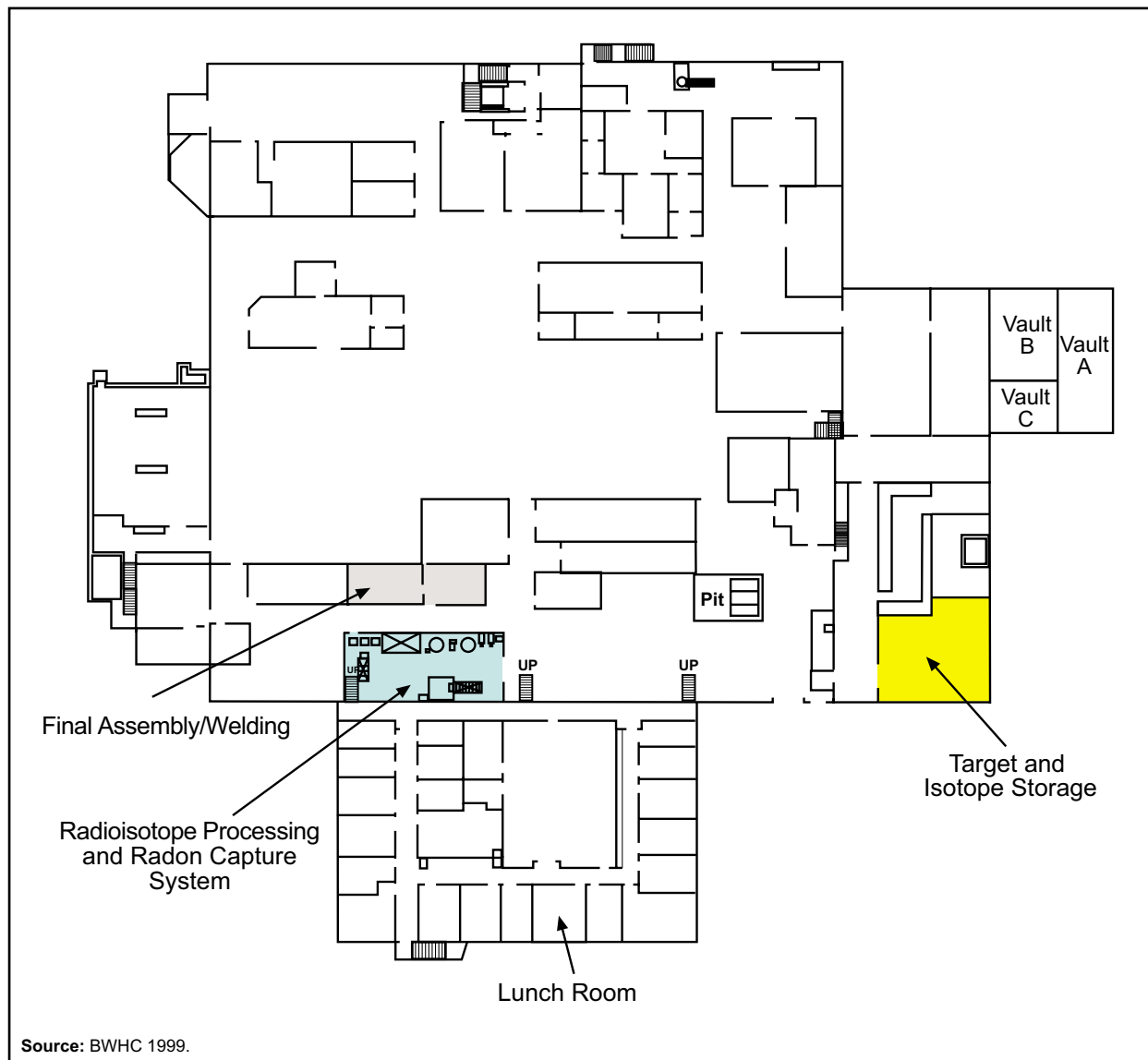
A special feature of RPL is the existence of two heavily shielded hot cell facilities located in annexes on the east and west sides of the building. These shielded facilities are the High-Level Radiochemistry Facility and the Shielded Analytical Laboratory. These two hot cell complexes are heavily used because they provide capabilities for conducting bench-scale to pilot-scale work with a wide variety of highly radioactive materials. Their capabilities include those required to conduct radiochemical separation and purification procedures, irradiated fuel or target sectioning and processing, metallography, physical properties testing of activated metals, thermal processing (including waste vitrification), and radioanalytical and preparatory chemistry operations.

The High-Level Radiochemistry Facility contains three large, interconnected hot cells designated as A-Cell, B-Cell, and C-Cell. Each of the three cells is 4.6 meters (15 feet) high and 2.1 meters (7.0 feet) deep. The A-Cell is 4.6 meters (15 feet) wide, and the B-Cell and C-Cell are each 1.8 meters (6.0 feet) wide. In-cell operations are performed using medium-duty electromechanical manipulators, and operators view their work through leaded-glass, oil-filled windows. Closed-circuit television cameras and videocassette recorders have been installed for detailed inspection work within the hot cells. The A-Cell and C-Cell also have overhead bridges that contain hoists with a 2,200-kilogram (4,840-pound) capacity. The hot cells are fully equipped with utilities and have shielded service penetrations at the front wall to allow insertion of special instruments. Each hot cell contains several process vessels located below the work deck that range in capacity from 4.0 to 320 liters (1.1 to 84.5 gallons). A large shielded door and a shielded double-door transfer port located in the rear wall of the cell provide access to each hot cell in the High-Level Radiochemistry Facility. Cask payloads weighing up to 2,200 kilograms (4,840 pounds) can be transferred into and out of the hot cells using a bridge crane located in the canyon behind the cells.

The Shielded Analytical Laboratory contains six interconnecting hot cells, each of which is 1.7 meters (5.5 feet) wide, 1.7 meters (5.5 feet) deep, and 2.9 meters (9.5 feet) high. Each hot cell is equipped with a pair of medium-duty manipulators. Turntables built into the rear walls of the hot cells provide rapid transfers of radioactive samples into and out of the cells. The Shielded Analytical Laboratory hot cells are equipped to perform a wide variety of analytical chemistry operations with highly radioactive samples.



**Figure 2–20 Proposed First Floor Locations for Hot Cell Operations and Radiochemical and Radioanalytical Laboratories for FFTF Target Processing**



**Figure 2-21 Proposed Basement Locations for Assembly, Processing, and Storage of FFTF Targets; Also Shown: Laboratory with Radon Gas Capture System to be Used for Processing Radium-226 Targets**

The primary features and functions of the laboratories within RPL that would be used for processing targets irradiated at FFTF are described below.

- A cluster of 10 laboratories would be available on the first floor of RPL. Each laboratory would contain a small hot cell, a shielded glovebox, and a fume hood with interconnecting transfer ports.
- A transfer port for receiving casks containing irradiated targets into the A-Cell of the High-Level Radiochemistry Facility would be installed, and provision would be made in the C-cell for initial processing of highly radioactive targets (e.g., irradiated europium targets containing gadolinium-153 product).

- Target preparation and storage areas would be provided in the basement of RPL, in close proximity to the facilities where the radioactive and recycled targets would be assembled and welded.
- A 139.4-square-meter (1,500-square-foot) laboratory equipped with a radon gas capture system would be available in the basement of RPL to process radium-226 targets and the product isotopes generated by irradiation of these targets (all of these targets generate radon gas as intermediate products in their decay chains) (BWHC 1999).

Detailed descriptions of the processes associated with medical and industrial isotope storage, target fabrication, and postirradiation processing are included in Appendix C.

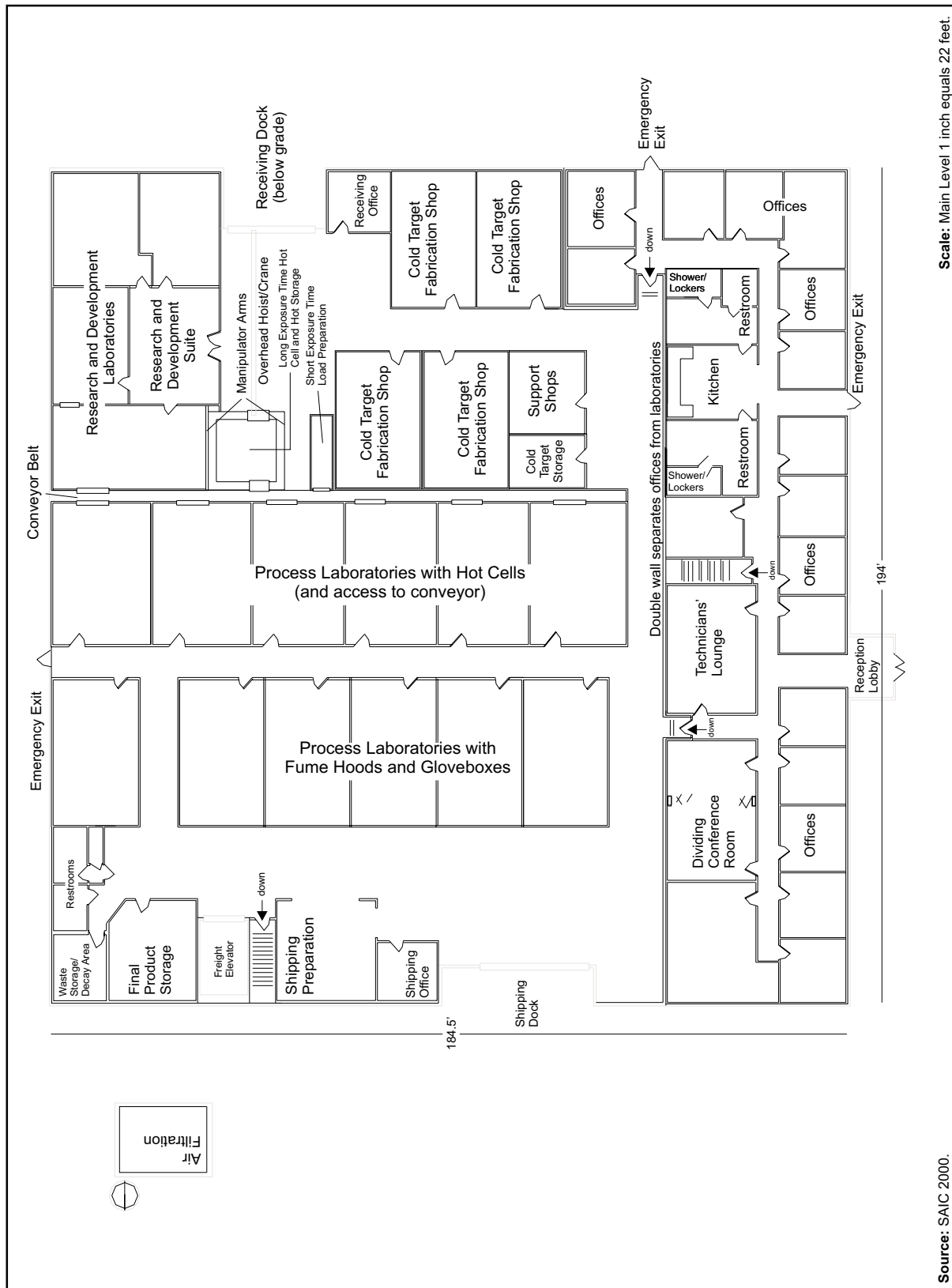
#### **2.3.2.5 New Support Facility**

A new generic support facility would have the mission of preparing targets for irradiation, processing exposed targets, and housing the materials research and development activities. Siting of the generic support facility for medical and industrial isotope production would require that the facility be located in the same general vicinity (0.2 to 20 kilometers [0.07 to 12.4 miles]) as the new irradiation facility (accelerator or reactor). Collocation with the irradiation facility would be needed to process some irradiated target materials promptly after removal from the reactor/accelerator because some isotopes have short half-lives. Collocation would also minimize transportation risks. Although the facility could be located within the irradiation facility security protection area, the lack of a defense mission and the lack of a fissile material presence in the generic support facility indicates that a high level of physical protection would not be warranted.

The generic support facility mission would be accommodated by a one-story, 3,300-square-meter (36,000-square-foot) above-grade building with a 1,475-square-meter (16,000-square-foot) basement area under a portion of the footprint (SAIC 2000). **Figure 2–22** provides the general layout of the building. The relative position and size of the processing, support, office, and research and development areas are shown on the diagram.

The facility is designed around a center area containing the highest-risk activities and the material inventories requiring the highest level of engineered controls. As can be seen in Figure 2–22, irradiated materials in casks or other shielded transport containers would enter a loading dock with a straight-line access to the primary facility hot cell. The hot sample entry area would be a high bay area with a high floor loading area between the loading dock and the hot cell access port. This configuration would allow transport cask access to the hot cell. In addition, an overhead hoist would be available to facilitate handling of materials and devices in the proximity of the hot cell.

The hot cell would accept high-radiation-level samples or those difficult to shield or manipulate (e.g., reactor core components containing samples). The hot cell would have access to a conveyor that can remotely transport samples to the hot process laboratories. In addition, samples from the hot cell could be transferred to the hot research and development laboratory gloveboxes for detailed analysis and testing. Hot cell manipulators would be located on both the operating gallery and the research and development sides of the hot cell. Adjacent to that would be the central receiving station for all other radioactive and short-exposure samples not in the reactor core components. This area, while not a hot cell, would provide personnel protection (i.e., shielding and controlled ventilation) for preliminary sample preparation and examination. It would also provide interim irradiated sample storage prior to delivery to the designated processing laboratory. When needed, samples would be transported remotely to the processing laboratories by the conveyor system. Samples requiring a lesser degree of control would be distributed for processing throughout the remaining process laboratory wing. After processing, the radiopharmaceuticals would be either stored or packaged and shipped immediately to offsite vendors. Radioactive waste would be packaged and stored for eventual



disposal. Those materials containing short-lived isotopes would be delivered to a decay/holding room so that, given appropriate decay time, they could be disposed of without a radioactive component. The process and research and development areas would be considered radiologically controlled areas, but no routinely occupied areas would require control as contaminated radiological areas. Radioactive contamination would be controlled at the hood or glovebox face. Due to this configuration, protective clothing and change rooms would be needed only for occasional maintenance activities when temporary radiological areas are established.

Cold sample (nonradioactive) preparation would be accomplished in a set of three large laboratories where radiological conditions are not anticipated. Completed samples would be stored in an adjacent room along with raw sample materials (nonradioactive).

Radioactive sample preparation and irradiated material recycling activities would be conducted in one of the laboratories adjacent to the conveyor.

Irradiated research and development samples introduced into the hot cell could be processed or examined using manipulators within the hot cell. Samples could also enter the research and development suite of lab rooms through the hot cell port into a hot cell or glovebox. From there, they could be moved to additional research and development laboratory rooms within a controlled environment for detailed analysis and testing.

Support areas would include ventilation, maintenance, change rooms, quality assurance and quality control, lunch and break rooms, storage, conference rooms, basement stairwells, equipment elevators, and utility distribution. A small machine shop would accommodate light machining activities, but would not be intended to involve radioactive materials. A portion of the support functions, especially utilities, would be located in a basement portion of the building. The basement would be located under the half of the building that would not experience high weight loads (i.e., hot cell, cask receiving area).

Solid waste would be collected, packaged, and stored at a central location. Liquid waste would be processed at the point of generation (e.g., hood/glovebox) or would be collected in a retention tank for characterization and eventual transfer to the effluent treatment facility.

## **2.4 DESCRIPTION OF TRANSPORTATION ACTIVITIES**

### **2.4.1 Purchase of Plutonium-238 from Russia**

Under the No Action Alternative (see Section 2.6.1), DOE would continue exercising its option to purchase Russian plutonium-238 (if available) to meet the needs of future U.S. space missions. In 1992, DOE signed a contract permitting the purchase from Russia of up to 40 kilograms (88.2 pounds) of plutonium-238. To date, DOE has purchased 9 kilograms (19.8 pounds). In 1997, DOE extended the contract for another 5 years, so this option remains viable. It is unclear, however, whether this option would remain reliable or viable once the existing contract expires (DOE 1997). The impacts associated with the purchase of plutonium-238 from Russia are discussed in Section 4.2.1.1.

### **2.4.2 Transportation of Plutonium-238 from St. Petersburg, Russia, to Los Alamos National Laboratory**

Plutonium-238 purchased from Russia would have to be transported from St. Petersburg to a U.S. port of entry, and from there to Los Alamos National Laboratory (LANL) where it would be used in the fabrication of radioisotope power systems. The impacts of the transportation of a total of 40 kilograms (88.2 pounds) of plutonium-238 are estimated in the *Environmental Assessment of the Import of Russian Plutonium-238* (DOE 1993) and are summarized in Section 4.2.1.1 of this NI PEIS. The impacts associated with transporting

175 kilograms (385 pounds) (5 kilograms [11 pounds] per year for the 35-year evaluation period) of plutonium-238 have been determined by extrapolation and are included in the same section.

#### **2.4.3 Transportation of Neptunium-237 from Savannah River Site to Candidate Storage Facilities**

Under the No Action Alternative (see Section 2.6.1) DOE would transport neptunium-237 oxide from SRS to a storage facility off site. Storage canisters containing the neptunium-237 oxide would be loaded into approved shielded shipping containers or casks at SRS and shipped to the designated storage facilities for long-term storage.

Truck transportation of neptunium-237 from SRS to the proposed storage facilities is assumed in this NI PEIS. The neptunium-237 would be transported in robust Type B transportation casks. Type B casks are used to transport nuclear materials with the highest radioactivity levels, and are designed to protect and retain their contents under transportation accident conditions. According to DOE policy, which requires compliance with applicable Federal regulations regarding domestic shipments of radioactive materials, transportation of neptunium-237 in Type B casks would comply with the requirements of 10 CFR Part 71, "Packaging and Transportation of Radioactive Materials," and 49 CFR Part 173, "Shippers - General Requirements for Shipping and Packaging."

The container that would be used to transport neptunium-237 has not been proposed, but would be a Type B container similar to the Chalfont container 9975. The 9975 container includes a 132-liter (35-gallon) drum, insulation, a primary containment vessel, a secondary containment vessel, lead shielding, and aluminum honeycomb spacers. The neptunium-237 would be sealed into a can, which would be placed on a honeycomb spacer inside the stainless steel primary containment vessel. The primary containment vessel would be bolted closed and placed into a similarly constructed, but larger, secondary containment vessel. The secondary containment vessel would be bolted closed and loaded into a drum equipped with lead shielding to reduce radiation levels and fireboard insulation to protect the containment vessels in the unlikely event of a severe impact. A description of the Chalfont container 9975 is provided in Appendix J.

DOE anticipates that neptunium-237 would be transported through use of the Transportation Safeguards System and shipped using SST/SGTs. The SST/SGT, a fundamental component of the Transportation Safeguards System, is a specially designed component of an 18-wheel tractor-trailer vehicle. Although details of vehicle enhancements and some operational aspects are classified, key characteristics of the SST/SGT system include the following:

- Enhanced structural characteristics and a highly-reliable tie-down system to protect cargo from impact
- Heightened thermal resistance to protect the cargo in case of fire (newer SST/SGT models)
- Established operational and emergency plans and procedures governing the shipment of nuclear materials
- Various deterrents to prevent unauthorized removal of cargo
- An armored tractor component that provides courier protection against attack and contains advanced communications equipment
- Specially designed escort vehicles containing advanced communications and additional couriers

- 24-hour-a-day real-time communications to monitor the location and status of all SST/SGT shipments via DOE's Security Communication system
- Couriers, who are armed Federal officers, receive rigorous specialized training and are closely monitored through DOE's Personnel Assurance Program
- Significantly more stringent maintenance standards than those for commercial transport equipment
- Conduct of periodic appraisals of the Transportation Safeguards System operations by the DOE Office of Defense Programs to ensure compliance with DOE orders and management directives, and continuous improvement in transportation and emergency management programs.

Additional details are presented in Appendix J.

#### **2.4.4 Transportation of Mixed Oxide Fuel from Europe to FFTF**

As discussed in Section 2.3.1.1.3, a 15-year supply of mixed oxide fuel may be available from Germany to operate FFTF. Approximately 205 mixed oxide fuel assemblies were fabricated in Europe for use in Germany's SNR-300 sodium cooled, breeder reactor before the German government suspended the reactor's operation. SNR-300 mixed oxide fuel is very similar both in composition and construction to FFTF fuel. The 205 SNR-300 mixed oxide fuel assemblies, if reconfigured for FFTF, could be used to fabricate about 150 to 160 FFTF fuel assemblies. This amount could supply two FFTF core loads for approximately 15 years of FFTF operation at the 100 megawatts thermal power level with occasional excursions to the 400 megawatts thermal power level on an as-needed basis (as proposed for this mission).

The inventory of unused SNR-300 mixed oxide fuel is now stored at Hanau, Germany, and Dounreay, Scotland. If a decision were made to use SNR-300 fuel in FFTF, security measures would be implemented to prevent unauthorized removal of the mixed oxide fuel during its transportation to the United States. The requirements to ensure the safety and security of transatlantic mixed oxide fuel shipments are listed in: *The Convention on the Physical Protection of Nuclear Material*, International Atomic Energy Agency publication INFCIRC 274 (IAEA 1997); *The Physical Protection of Nuclear Material*, International Atomic Energy Agency publication INFCIRC 225 (IAEA 1999); the *Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes in Flasks on Board Ships* (IMO 1993); DOE orders; and 10 CFR Part 73. DOE estimates that as many as 11 shipments would be required. The initial shipment would transport the FFTF mixed oxide fuel lead test assembly and the following 5 to 10 shipments would transport the SNR-300 fuel assemblies reconfigured for FFTF use.

SNR-300 mixed oxide fuel could be brought into many U.S. commercial and military ports. A port-selection process was used by DOE in its *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (Foreign Research Reactor Spent Nuclear Fuel EIS)* (DOE 1996). The criteria used for screening ports in the *Foreign Research Reactor Spent Nuclear Fuel EIS* were: (1) appropriate port experience; (2) safe port transit to open ocean; (3) appropriate port facilities for safe receipt, handling and transshipment; (4) ready intermodal access; and (5) low human population of the ports and along transportation routes. DOE used these same criteria to identify ports for receiving mixed oxide fuel from Europe. The application of these criteria for mixed oxide fuel is discussed in Section J.3.6.1.

In the *Foreign Research Reactor Spent Nuclear Fuel EIS* Record of Decision, DOE decided to use military ports to take advantage of their characteristics to increase the safety and security of the spent fuel transportation process. DOE concluded that the use of military ports provides additional confidence in the

safety of shipments due to the increased security. Since the security issues are far greater for fresh mixed oxide fuel than for spent nuclear fuel because of the potential for proliferation, DOE would use a military port to bring the SNR-300 mixed oxide fuel into the country.

The following military ports were considered:

In the Eastern United States: Charleston Naval Weapons Station, South Carolina; Military Ocean Terminal Sunny Point, North Carolina; Mayport, Florida; Kings Bay, Georgia; Pensacola, Florida; Yorktown, Virginia; and Hampton Roads, Virginia.

In the Western United States: Military Ocean Terminal Bay Area, California; Bremerton, Washington; Everett, Washington; Port Hueneme, California; and Port Townsend, Washington.

The overland transportation impacts would be somewhat higher if mixed oxide fuel were accepted at an east coast port rather than a west coast port. However, accepting mixed oxide fuel at an east coast port reduces time and eliminates the potential security risk when transiting the Panama Canal making it preferable to accepting it at a west coast port. The east coast port of Charleston Naval Weapons Station was used for the purpose of transportation impact analysis. This preference which includes the impacts on the global commons (i.e., portions of the ocean not within the territorial boundary of any nation) in accordance with Executive Order 12114 (44 FR 1957), the impacts approaching and docking at the port, and the impacts of unloading the mixed oxide package at the port (see Section J.6.2).

Use of a military port to receive SNR-300 mixed oxide fuel would require shipment via chartered ships. The ships that would be used to transport SNR-300 mixed oxide fuel to the United States would be of the type used to transport spent nuclear fuel or mixed oxide fuel internationally. These specially equipped ships are called purpose-built vessels.

Purpose-built vessels, as used in this NI PEIS, are those vessels specifically designed to transport nuclear fuel casks. These vessels operate as dedicated vessels and, therefore, are not used to transport any other cargoes. Casks are loaded directly into the hold of the vessel because the cargo compartments contain hardware that mates to the tie-down fixtures on the casks. If the vessel has no crane, dockside cranes are used for loading and unloading. The cargo compartments are typically intended to handle a specific type of cask, and other cask types cannot be used without making modifications to the tie-down hardware.

The purpose-built vessels are equipped with double bottoms and hulls, watertight compartments, special firefighting systems, and collision-damage-resisting structures within the main hull, as well as special security features and satellite tracking systems. The crew is trained in appropriate cargo-handling techniques and in emergency response.

At present, purpose-built vessels are operated by Pacific Nuclear Transport Services of Japan, by British Nuclear Fuels, Limited, and by the Swedish Nuclear Fuel and Waste Management Company. They are used to move nuclear fuel between operating nuclear power plants and nuclear fuel reprocessing facilities operated by Cogema and British Nuclear Fuels, Limited, or in Sweden's case, the repository in Forsmark. Beginning in 1998, purpose-built vessels have transported spent nuclear fuel from foreign research reactors to the Charleston Naval Weapons Station. Additionally, in 1999 purpose-built vessels delivered mixed oxide fuel from the United Kingdom to Japan. There are no U.S.-owned purpose-built vessels for nuclear fuel transport.

DOE anticipates that the SNR-300 mixed oxide fuel would be transported overland from the seaport to FFTF using the same Transportation Safeguards System that would be required for the transportation of neptunium-237 (see Section 2.4.3).

The environmental impacts associated with importing SNR-300 mixed oxide fuel from Europe are discussed in Section 4.3 and Appendix J.

#### **2.4.5 Transportation of Neptunium-237 from Savannah River Site to Target Fabrication Facilities**

The neptunium-237 required for target fabrication in the production of plutonium-238 is currently stored at SRS. Therefore, transportation of neptunium-237 oxide from SRS to target fabrication facilities off site (REDC, FDPF, FMEF) would be required. Storage canisters containing the neptunium-237 would be loaded into approved shielded shipping containers or casks at SRS and shipped to the target fabrication facilities. Transportation of neptunium-237 from SRS to these facilities for long-time storage is discussed in Section 2.4.3.

#### **2.4.6 Transportation of Nonirradiated and Irradiated Targets**

Transportation of nonirradiated neptunium-237 targets from the target fabrication facility to the irradiation facility and irradiated targets from the irradiation facility back to the fabrication facility for processing would use Type B casks certified for the safe shipments of the neptunium-237 targets. The casks used would be similar in size and construction to a spent nuclear fuel cask. Neptunium-237 targets would most likely be shipped in commercial trucks. The cask selection and environmental issues are discussed in Appendix J.

#### **2.4.7 Transportation of Plutonium-238 Product to LANL**

After postirradiation processing at the target processing facility, the plutonium-238 product in oxide form would be packaged and shipped to LANL. The 5320 cask, designed for surface transportation of americium or plutonium, would be used to carry plutonium oxide to LANL. The 5320 package is a dome-topped upright cylinder that is mounted on a baseplate supported by casters. The plutonium-238 would be loaded into an EP-60 product canister, a stainless steel shell confinement vessel used to load the product into the package safely and conveniently. The EP-60 would be seal-welded into the removable stainless steel shell primary containment vessel, the EP-61. The EP-61 would be placed into the secondary containment vessel, the EP-62. The stainless steel EP-62 has a removable bolted closure lid. The gasketed flange of the EP-62 satisfies the containment requirements for both normal transport and hypothetical accident conditions. Plutonium oxide would be transported using the Transportation Safeguards System and would be shipped using SST/SGT (see Section 2.4.3).

#### **2.4.8 Transportation of Materials for Medical Isotope Production**

The raw material for target fabrication would typically be acquired from ORNL, where enrichment processes are conducted to produce high purity target material suitable for production of medical isotopes. The raw material would be shipped from ORNL to Hanford or to the new generic support facility at an existing but undefined DOE site.

Transportation of materials for medical and industrial isotope production and research and development would take place at Hanford between FFTF and the Hanford RPL/306-E facilities or FMEF. At the existing DOE site, transportation would take place between the new generic support facility and either the new low-energy accelerator or the new research reactor.

At Hanford, two different target irradiation vehicle assemblies would be used—the Long-Term Irradiation Vehicle Assembly (up to 3.7 meters [12 feet] in length) and the Rapid Radioisotope Retrieval System Target Carrier (less than 1 foot in length). Irradiated pins or short target carriers would be shipped from the irradiation facility to the processing facility using a Type B, accident-resistant shipping cask. The elements (or pins) for

the Long-Term Target Irradiation Vehicle Assemblies would be segmented in the FFTF Interim Examination and Maintenance cell, if necessary, or could be inserted directly into the shipping cask; the Rapid Retrieval System Target Vehicle Assemblies would be inserted into a smaller “shielded pig” package, which would be inserted into the shipping cask or, ideally and as a design goal, the irradiated target carriers would be loaded directly into the shipping cask from the reactor.

At the existing DOE site, irradiated targets and research and development material would be transported in a “shielded pig” package from either the new low-energy accelerator or the new research reactor to the new generic support facility.

A variety of casks would be used to ship the separated isotopes from the processing facility to the destination (i.e., the pharmaceutical distributor). Some land and air shipments would use DOT-specified casks such as CI-20WC-2, and others would require larger Type B casks.

An existing licensed irradiated fuel shipping cask (the T-3) is available to transport material used for research and development. This cask can accommodate shipments of pins or FFTF fuel assemblies as well as nonfuel experiments and materials.

## **2.5 DESCRIPTION OF ALTERNATIVES**

A perspective on the programmatic activities associated with the options under each alternative is presented in **Table 2–3**. Individual alternatives are described in the following sections. The environmental impacts associated with each alternative and its options are discussed in Chapter 4 and are summarized in Section 2.7.

### **2.5.1 No Action Alternative**

Under the No Action Alternative (maintain status quo), FFTF would be maintained in standby status for all or a portion of the 35-year evaluation period for operations covered in this NI PEIS. For the purpose of analysis in this NI PEIS, the maximum period of 35 years was assumed. Ongoing operations at existing facilities as described in Chapter 3, Affected Environment, would continue under this alternative. DOE would not establish a domestic plutonium-238 production capability, but could, instead, continue to purchase Russian plutonium-238 to meet the needs of future U.S. space missions. For the purpose of analysis in this NI PEIS, DOE assumed that it would continue to purchase plutonium-238 to meet the space mission needs for the 35-year evaluation period. However, DOE recognizes that any purchase beyond what is currently available to the United States through the existing contract may require additional NEPA review. DOE would continue its medical and industrial isotope production and nuclear research and development activities at the current operating levels of existing facilities. A consequence of a No Action decision would be the need to determine the future of the neptunium-237 stored at SRS. Therefore, the impacts of possible future transportation and storage of neptunium-237 are evaluated as part of the No Action Alternative. Four options are identified. If DOE decides not to establish a domestic plutonium-238 production capability in the future, the neptunium-237 would have no programmatic value and Option 1 would be selected. Conversely, if DOE decides to maintain the capability to establish a domestic plutonium-238 capability in the future, the inventory of neptunium-237 must be retained. In this case, Option 2, 3, or 4 could be selected.

- **Option 1.** Under this option, DOE would reconsider its stabilization strategy for the neptunium-237, currently stored in solution form at SRS, possibly leading to final disposition. The current plan is to stabilize the material to oxide, as described in the Supplemental Record of Decision for the *Final Environmental Impact Statement, Interim Management of Nuclear Materials at SRS* (DOE 1995c; 62 FR 61099, 1997). This Record of Decision would be amended or new NEPA analysis performed, if necessary.

Table 2–3 Alternatives and Options Matrix

Activity	Irradiation Facility and Site	Target Fabrication and Processing Facility Site	No Action Alternative	Alternative 1 <sup>a</sup>						Alternative 2 <sup>b</sup>									Alternative 3 <sup>c</sup>			Alternative 4 <sup>d</sup>			Alternative 5 <sup>e</sup>		
			Options	Options						Options									Options			Options					
			1	2	3	4	1	2	3	4	5	6	1	2	3	4	5	6	7	8	9	1	2	3		1	2
Store neptunium-237 as oxide		REDC at ORNL		●																							
		CPP-651 at INEEL				●																					
		FMEF at Hanford							●																		
Purchase plutonium-238			●	●	●	●																					
Irradiate targets for plutonium-238 production	FFTF at Hanford: mixed oxide fuel: 21 years; highly enriched uranium: 14 years							●	●	●																	
	FFTF at Hanford: mixed oxide fuel: 6 years; highly enriched uranium: 29 years										●	●	●														
	ATR at INEEL													●	●	●											
	CLWR (generic site)														●	●	●										
	ATR at INEEL plus HFIR at ORNL																	●	●	●							
	New high-energy accelerator at generic DOE site																				●	●	●				
	New research reactor (generic DOE site)																							●	●	●	
		REDC at ORNL						●			●			●			●				●			●			
Store neptunium-237 and fabricate and process targets for plutonium-238 production		FDPF and CPP-651 <sup>1</sup> at INEEL						●			●			●			●					●			●		
		FMEF at Hanford									●			●			●			●			●			●	
Irradiate targets for medical and industrial isotope production and perform research and development activities	FFTF at Hanford: mixed oxide fuel: 21 years; highly enriched uranium: 14 years							●	●	●																	
	FFTF at Hanford: mixed oxide fuel:6 years; highly enriched uranium: 29 years										●	●	●														
	New low-energy accelerator at generic DOE site																				●	●	●				
	New research reactor at generic DOE site																							●	●	●	
Fabricate and process targets for medical and industrial isotope production and perform research and development activities		FMEF at Hanford									●																
		RPL/306-E						●	●		●	●															
		New facility (generic DOE site)																				●	●	●	●	●	●
Maintain FFTF in standby status	FFTF at Hanford		●	●	●	●																					
Deactivate FFTF	FFTF at Hanford												●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

a. Alternative 1, restart FFTF.

b. Alternative 2, use only existing operational facilities.

c. Alternative 3, construct new accelerator(s).

d. Alternative 4, construct new research reactor.

e. Alternative 5, permanently deactivate FFTF (with no new missions).

f. CPP-651 would be used only for storage.

- **Options 2 through 4.** Under these options, the neptunium-237 oxide would be transported from SRS to one of three candidate DOE sites for up to 35 years of storage. For the purpose of analysis in this NI PEIS, the maximum period of 35 years was assumed. Option 2 would provide storage at ORNL's REDC facility, Option 3 at INEEL's Building CPP-651, and Option 4 at Hanford's FMEF.

## **2.5.2 Alternative 1—Restart FFTF**

Under Alternative 1, FFTF at Hanford would be restarted and operated for the 35-year evaluation period. FFTF would be used to irradiate targets for medical and industrial isotopes production, plutonium-238 production, and nuclear research and development irradiation requirements. Ongoing operations at existing facilities as described in Chapter 3, Affected Environment, would continue.

Targets for medical and industrial isotope production would be fabricated in one or more facilities at Hanford. Target material would typically be acquired from ORNL, where enrichment processes are conducted to produce high purity target material suitable for production of medical isotopes. The targets would be irradiated at FFTF and then returned to the fabrication facility for postirradiation processing. From there, the isotope products would be sent directly to commercial pharmaceutical distributors.

Targets for plutonium-238 production would be fabricated in one of three candidate facilities at ORNL, INEEL, or Hanford. The material needed for target fabrication (neptunium-237) would be transported from the fabrication facilities. The nonirradiated targets would be transported and irradiated at FFTF and transported back to the fabricating facilities for postirradiation processing. The separated plutonium-238 would be transported to LANL for fabrication into heat sources for radioisotope power systems.

Under Alternative 1, raw materials, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for raw target material acquisition, material storage, target fabrication, target irradiation, and postirradiation processing and the final destination for the medical and industrial isotopes and the plutonium-238 product or various research and development test sites.

FFTF could produce high-energy neutrons and a large flux level ( $10^{15}$  neutrons per square centimeter per second) that can be tailored to nearly any desired energy level. FFTF would provide the greatest flexibility for both isotope production and nuclear-based research and development among the baseline configurations for all of the proposed alternatives. Due to its large core size, flux spectrum, demonstrated testing capability, and rated power level, it would be able to concurrently support the projected plutonium-238 needs, production of medical and industrial isotopes (including those isotopes normally produced in particle accelerators), and nuclear research and development related to a broad range of materials, advanced reactors, advanced fuels and waste transmutation.

The six options under this alternative are associated with the type of nuclear fuel to be used for FFTF operations and the specific facilities to be used for target fabrication and processing. The first three options (Options 1 through 3) would involve operating FFTF with a mixed oxide fuel core for the first 21 years and a highly enriched uranium fuel core for the remaining 14 years. The last three options (Options 4 through 6) would involve operating FFTF with a mixed oxide fuel core for the first 6 years and a highly enriched uranium fuel core for the remaining 29 years. FFTF can provide similar irradiation services with either a mixed oxide core or a highly enriched uranium core. The reasons for these options in FFTF core fuel are provided in Section 2.3.1.1.3.

The options involving storage, fabrication, postirradiation processing, and transportation are discussed below.

- **Options 1 and 4.** REDC at ORNL would be used to fabricate and process the neptunium-237 targets required for plutonium-238 production. The neptunium-237 transported from SRS to ORNL would be stored in REDC. The plutonium-238 product would be transported from ORNL to LANL. Hanford's RPL/306-E facilities would be used to fabricate and process targets for medical and industrial isotope production and for research and development, as well as to store the materials needed to fabricate these targets.
- **Options 2 and 5.** FDPF at INEEL would be used to fabricate and process the neptunium-237 targets for plutonium-238 production. The neptunium-237 transported from SRS to INEEL would be stored in FDPF or Building CPP-651 at INEEL. The plutonium-238 product would be transported from INEEL to LANL. Hanford's RPL/306-E facilities would be used to fabricate and process targets for medical and industrial isotope production and for research and development, as well as to store the materials needed to fabricate these targets.
- **Options 3 and 6.** FMEF at Hanford would be used to fabricate and process both neptunium-237 targets for plutonium-238 production and the targets for the production of medical and industrial isotopes. The neptunium-237 transported from SRS to Hanford and the other target materials transported from other offsite facilities to Hanford would be stored in FMEF. The plutonium-238 product would be transported from Hanford to LANL for fabrication into heat sources for radioisotope power systems.

### **2.5.3 Alternative 2—Use Only Existing Operational Facilities**

Under Alternative 2, DOE would use existing operating DOE reactors or U.S. commercial nuclear power plants to produce plutonium-238 for future space missions. The production of medical and industrial isotopes and support of nuclear research and development in DOE reactors and accelerators would continue at the No Action Alternative levels. However, the currently operating DOE reactors, HFIR and ATR, cannot fully meet the projected long-term needs for medical isotope production and nuclear research and development with or without adding the plutonium-238 production mission.

Depending on the combination of facilities used in Alternative 2, HFIR and ATR could continue their current support of the medical and industrial isotope and research and development missions, including some near-term growth, while accommodating the production of plutonium-238. Under other scenarios, some of the near-term growth in medical and industrial isotope production and nuclear research and development, possible in these reactors, could be limited by the addition of the plutonium-238 production. In any case, non-DOE use of these facilities would be affected by the addition of the plutonium-238 mission. If a commercial reactor were used for plutonium-238 production, the DOE facilities would be unaffected and would continue operating as discussed under the No Action Alternative.

Another component of Alternative 2 is permanent deactivation of FFTF. Permanent deactivation of FFTF (Alternative 5) could occur in conjunction with any of the options under Alternatives 2, 3, or 4. Ongoing operations at existing facilities as described in Chapter 3, Affected Environment, would continue under Alternative 2.

Targets for plutonium-238 production would be fabricated in one of three facilities at ORNL, INEEL, or Hanford. The material needed for target fabrication (neptunium-237) would be processed and transported from SRS to the fabrication facilities. The targets would be irradiated at existing reactor facilities (HFIR, ATR,

CLWR, as described in Section 2.3.1) and would be transported back to the fabricating facilities for postirradiation processing.

Under Alternative 2, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for storage, target fabrication, target irradiation, and postirradiation processing, as well as transportation of the plutonium-238 product to LANL.

Nine options are proposed under this alternative. Options 1 through 3 involve the irradiation of targets in ATR at INEEL. Options 4 through 6 involve the irradiation of targets in a generic CLWR. Options 7 through 9 involve the irradiation of targets in both INEEL's ATR and ORNL's HFIR. These options and the associated target fabrication, postirradiation processing, and transportation activities are discussed below.

- **Option 1.** REDC at ORNL would be used to store the neptunium-237 transported from SRS to ORNL and to fabricate and process the targets irradiated at ATR. Option 1 also involves transportation of the neptunium-237 targets from ORNL to INEEL for irradiation in ATR, transportation of the irradiated targets from INEEL back to ORNL for postirradiation processing, and subsequent transportation of the plutonium-238 product from ORNL to LANL following postirradiation processing.
- **Option 2.** FDPF at INEEL would be used to store the neptunium transported from SRS to INEEL and to fabricate and process the targets (irradiated at ATR). Building CPP-651 would also be used for storage. Option 2 also involves transportation of the plutonium-238 product from INEEL to LANL following postirradiation processing.
- **Option 3.** FMEF at Hanford would be used to fabricate and process the targets (irradiated at ATR) and to store the neptunium-237 transported from SRS to Hanford. Option 3 also involves transportation of the neptunium-237 to Hanford for target fabrication, transportation of the targets from Hanford to INEEL for irradiation, transportation of the irradiated targets back to Hanford for postirradiation processing in FMEF, and subsequent transportation of the plutonium-238 product from Hanford to LANL.
- **Option 4.** REDC at ORNL would be used to store the neptunium-237 transported from SRS to ORNL and to fabricate and process the targets (irradiated at a generic CLWR). Option 4 also involves transportation of the neptunium-237 targets from ORNL to the generic CLWR location for irradiation, transportation of the irradiated targets back to ORNL for postirradiation processing, and transportation of the plutonium-238 product from ORNL to LANL.
- **Option 5.** FDPF at INEEL would be used to store the neptunium transported from SRS to INEEL and to fabricate and process the targets (irradiated at a generic CLWR). Building CPP-651 would also be used for storage. In addition, Option 5 involves transportation of the neptunium-237 targets from INEEL to the generic CLWR location for irradiation, transportation of the irradiated targets back to INEEL for postirradiation processing, and transportation of the plutonium-238 product from INEEL to LANL.
- **Option 6.** FMEF at Hanford would be used to store the neptunium-237 transported from SRS to Hanford and to fabricate and process the targets (irradiated at a generic CLWR). Option 6 also involves transportation of neptunium-237 to Hanford for target fabrication, transportation of the targets from Hanford to the generic CLWR location for irradiation, transportation of the irradiated targets back to Hanford for postirradiation processing, and transportation of the plutonium-238 product from Hanford to LANL.

- **Option 7.** REDC at ORNL would be used to store the neptunium-237 transported from SRS to ORNL and to fabricate and process the targets (irradiated at ATR and HFIR). Option 7 also involves transportation of the neptunium-237 targets from ORNL to the reactors for irradiation, transportation of the irradiated targets back to ORNL for processing, and transportation of the plutonium-238 product from ORNL to LANL.
- **Option 8.** FDPF at INEEL would be used to store the neptunium transported from SRS to INEEL and to fabricate and process the targets (irradiated at ATR and HFIR). Building CPP-651 would also be used for storage. Option 8 also involves transportation of the neptunium-237 targets from INEEL to the reactors for irradiation, transportation of the irradiated targets back to INEEL for postirradiation processing, and transportation of the plutonium-238 product from INEEL to LANL.
- **Option 9.** FMEF at Hanford would be used to store the neptunium-237 transported from SRS to Hanford and to fabricate and process the targets (irradiated at ATR and HFIR). Option 9 also involves transportation of neptunium-237 to Hanford for target fabrication, transportation of the targets from Hanford to the reactors for irradiation, transportation of the irradiated targets back to Hanford for postirradiation processing, and transportation of the plutonium-238 product from Hanford to LANL.

#### **2.5.4 Alternative 3—Construct New Accelerator(s)**

Under Alternative 3, one or two new accelerators would be used for target irradiation for the evaluation period of 35 years. The new accelerator(s), which would be constructed at an existing DOE site, would be used to irradiate all of the targets (i.e., for production of plutonium-238, isotopes for medical and industrial uses, and materials testing for research and development). Ongoing operations at existing facilities as described in Chapter 3, Affected Environment, would continue.

The targets for plutonium-238 production would be fabricated in one of the three candidate facilities at ORNL, INEEL, or Hanford. The material needed for the target fabrication (neptunium-237) would be transported from SRS to the fabrication facilities. The targets would be irradiated at the new high-energy accelerator facility and transported back to the target fabrication facilities for postirradiation processing.

Targets for medical and industrial isotope production would be fabricated in a new support facility located at the same site as the low-energy accelerator. The targets would be irradiated in the low-energy accelerator and returned to the new support facility for postirradiation processing. Site selection for Alternative 3 is not evaluated as part of this NI PEIS. Because Alternative 3 is evaluated at a generic DOE site, no credit was taken for any support infrastructure existing at the site and it was postulated that a new support facility would be required to support operation of the low-energy accelerator and its missions and the high-energy accelerator nuclear research and development missions if both accelerators are located on the same site. While this approach bounds the environmental impact assessment for the implementation of Alternative 3, it overstates the impacts because this NI PEIS integrates the impacts associated with constructing new support facilities and infrastructure that may be available at the existing DOE site. In the event that Alternative 3 or the low-energy accelerator alone is selected by the Record of Decision for subsequent consideration, follow-on NEPA assessments would evaluate potential locations for either both accelerators or one of the accelerators. It is highly unlikely that DOE would consider locating the new low-energy or high-energy accelerator on a DOE site that does not have existing infrastructure capable of supporting all or most of the proposed mission requirements.

DOE can select any alternative or combination of alternatives or elements of alternatives in the Record of Decision associated with this NI PEIS. Alternative 3 is a prime example of an alternative that could be split

and combined with another alternative. DOE could select Alternative 2 in combination with the new low-energy accelerator element of Alternative 3. This combination of alternative elements would provide the plutonium-238 production requirements, enhanced nuclear research and development capability, and enhanced medical and industrial isotope production capability.

Under Alternative 3, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for storage, target fabrication, target irradiation, postirradiation processing, and the final destination of the plutonium-238. Alternative 3 also would include decontamination and decommissioning of the accelerator(s) and the support facility when the missions are over, as well as deactivation of FFTF at Hanford.

The low-energy accelerator would serve as a dedicated isotope production facility. Due to the nature of this type of accelerator, it could only produce a limited number of isotopes (listed in Table 1–1), has no ability to satisfy the plutonium-238 needs, and a very limited ability to support the proposed nuclear-based research and development needs. The preconceptual design of the high-energy accelerator presented in Appendix F focused on supporting the plutonium-238 production mission. The design of the high-energy accelerator could be refined and expanded to perform additional missions such as the production of a select set of medical and industrial radioisotopes. In addition, DOE is aware of longer-term concepts that would apply high-energy accelerators to produce “tuneable” neutrons in a subcritical assembly. Such a facility could be used to address some of the missions more familiar to reactor facilities and may hold considerable promise for future science and technology research. A facility of this nature could provide unique capabilities in areas such as the testing of many different nuclear system coolant, fuel, and material interactions. The changes required to add additional capability to the high-energy accelerator could be provided, but they would increase the size of the facility, add complexity to the facility design and operation, increase the cost of construction and operation, and potentially require more time for design and construction.

The three options under this alternative and their associated target fabrication, postirradiation processing, and transportation activities are discussed below.

- **Option 1.** REDC at ORNL would be used to fabricate and process the neptunium-237 targets required for plutonium-238 production. The neptunium-237 transported from SRS to ORNL would be stored at REDC. The plutonium-238 product would be transported from ORNL to LANL for use in radioisotope power systems for future U.S. space missions. A new support facility at an existing DOE site would be used to fabricate and process the targets required for the production of medical and industrial and research isotopes and to store the materials needed for target fabrication.
- **Option 2.** FDPF at INEEL would be used to fabricate and process the neptunium-237 targets associated with plutonium-238 production. The neptunium-237 transported from SRS to INEEL would be stored in FDPF or Building CPP–651 at INEEL. The plutonium-238 product would be transported from INEEL to LANL for use in radioisotope power systems for future U.S. space missions. A new support facility at an existing DOE site would be used to fabricate and process the targets required to produce medical and industrial and research isotopes and to store the materials needed for target fabrication.
- **Option 3.** FMEF at Hanford would be used to fabricate and process the neptunium-237 targets for plutonium-238 production. The neptunium-237 transported from SRS to Hanford would be stored in FMEF. The plutonium-238 product would be transported from Hanford to LANL. A new support facility at an existing DOE site would be used to fabricate and process the targets required for the production of medical and industrial and research isotopes and to store the materials needed for target fabrication.

### **2.5.5 Alternative 4—Construct New Research Reactor**

Under Alternative 4, a new research reactor would be used for target irradiation for the evaluation period of 35 years. The new research reactor, to be constructed at an existing DOE site, would be used to irradiate all targets (i.e., for the production of plutonium-238, isotopes for medical and industrial uses, and materials testing for nuclear research and development). Ongoing operations at existing facilities as described in Chapter 3, Affected Environment, would continue.

The targets for plutonium-238 production would be fabricated in one of the three candidate facilities at ORNL, INEEL, or Hanford. The material needed for the target fabrication (neptunium-237) would be transported from SRS to the fabrication facilities. The targets would be irradiated at the new research reactor facility and transported back to the target fabrication facilities for postirradiation processing.

Targets for medical and industrial isotope production would be fabricated in a new support facility located at the same site as the new research reactor. The targets would be irradiated in the new research reactor and returned to the new support facility for postirradiation processing.

Alternative 4 site selection is not evaluated as part of this NI PEIS. Because Alternative 4 is evaluated at a generic DOE site, no credit was taken for any existing support infrastructure existing at the site and it was postulated that a new support facility would be required to support operation of the new research reactor and its missions. While this approach bounds the environmental impact assessment for the implementation of Alternative 4, it overstates the impacts because this NI PEIS integrates the impacts associated with constructing new support facilities and infrastructure that may be available at the existing DOE site. In the event that Alternative 4 is selected by the Record of Decision for subsequent consideration, follow-up NEPA assessments would evaluate potential locations for the new research reactor. It is highly unlikely that DOE would consider locating the new research reactor on a DOE site that does not have existing infrastructure capable of supporting all or most of the proposed medical and industrial isotope production and nuclear research and development mission requirements.

Under Alternative 4, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for storage, target fabrication, target irradiation, postirradiation processing, and the final destination of the plutonium-238. Alternative 4 also would include the decontamination and decommissioning of both the research reactor and the support facility when the missions are over, as well as deactivation of FFTF at Hanford.

The proposed new research reactor would provide ample neutrons for the production of plutonium-238 and for many of the isotopes listed in Table 1–1. The thermal flux would limit the new research reactor's ability to produce a number of isotopes requiring fast or high-energy neutrons. Its lower flux levels ( $10^{13}$  neutrons per square centimeter per second) and predominantly thermal flux would limit its ability to support many of the projected nuclear-based research and development needs.

The three options under this alternative and their associated target fabrication, postirradiation processing, and transportation activities are discussed below.

- **Option 1.** REDC at ORNL would be used to fabricate and process the neptunium-237 targets associated with plutonium-238 production. The neptunium-237 transported from SRS to ORNL would be stored at REDC. The plutonium-238 product would be transported from ORNL to LANL. A new support facility at an existing DOE site would be used to fabricate and process the targets

required for the production of medical and industrial and research isotopes and to store the materials needed for target fabrication.

- **Option 2.** FDPF at INEEL would be used to fabricate and process the neptunium-237 targets associated with plutonium-238 production. The neptunium-237 transported from SRS to INEEL would be stored in FDPF or Building CPP-651. The plutonium-238 product would be transported from INEEL to LANL. A new support facility at an existing DOE site would be used to fabricate and process the targets required for the production of medical and industrial and research isotopes and to store the materials needed for target fabrication.
- **Option 3.** FMEF at Hanford would be used to fabricate and process neptunium-237 targets for plutonium-238 production. The neptunium-237 transported from SRS to Hanford would be stored in FMEF. The plutonium-238 product would be transported from Hanford to LANL. A new support facility at an existing DOE site would be used to fabricate and process the targets required for the production of medical and industrial and research isotopes and to store the materials needed for target fabrication.

## **2.5.6 Alternative 5—Permanently Deactivate FFTF (with No New Missions)**

Under Alternative 5, DOE would permanently deactivate FFTF, with no new missions. Medical and industrial isotope production and nuclear research and development missions, at the existing facilities described in Chapter 3, would continue. DOE's nuclear facilities infrastructure would not be enhanced. Plutonium-238 required to support future U.S. space missions could be purchased from Russia.

## **2.6 ALTERNATIVES CONSIDERED AND DISMISSED**

In developing a range of reasonable alternatives, DOE examined the capabilities and available capacities of the existing and planned nuclear research facilities (accelerators, reactors, and processing [hot] cells) that potentially could be used to support one or all of the proposed isotope production and research missions (DOE 2000a). The following facilities were initially considered, but were subsequently dismissed as reasonable alternatives for meeting DOE's proposed nuclear infrastructure mission requirements.

### **2.6.1 Irradiation Facilities Dismissed**

DOE evaluated the irradiation capabilities of existing government, university, and commercial irradiation facilities to determine whether they could significantly support the proposed expanded nuclear infrastructure missions. **Table 2-4** presents irradiation facilities that were initially considered but dismissed from further evaluation because they lacked technical capability or available capacity. Reasons for lacking technical capability include that the facility has been permanently shut down, it does not possess the capability to produce steady-state neutrons, or that it could not maintain sufficient power levels to adequately support steady-state neutron production. Facilities were similarly dismissed if existing capacity was fully dedicated to existing missions, or if use of existing capacity to support this NI PEIS proposed action would impact existing missions. Although a number of facilities shown in Table 2-4 have the same available capacity, their combined available capacity is a very small percentage of the capacity needed to support the missions evaluated in this NI PEIS.

**Table 2–4 Irradiation Facilities Considered but Dismissed from Further Evaluation**

Facilities lacking sufficient neutron production capacity to support the NI PEIS proposed action without impacting existing missions	Neutron Radiographic Reactor Argonne National Laboratory–West
	Brookhaven Medical Research Reactor Brookhaven National Laboratory
	National Bureau of Standards Reactor National Institute of Standards and Technology
	General Atomics Training, Research, and Isotope Production Reactors
	University Small Research Reactors
	University Large Research Reactors (i.e., Massachusetts Institute of Technology and University of Missouri)
	ATLAS Heavy Ion Facility Argonne National Laboratory
	Holifield Radioactive Ion Beam Facility Oak Ridge National Laboratory
	Heavy Ion Linear Accelerator Lawrence Berkeley National Laboratory
	Alternating Gradient Synchrotron Heavy Ion Facility Brookhaven National Laboratory
	Continuous Electron Beam Accelerator Facility Thomas Jefferson National Accelerator Facility
	Electron Linear Accelerator Lawrence Livermore National Laboratory
	University Linear Accelerators
Facilities with capacity fully dedicated to existing missions	Annular Core Research Reactor Sandia National Laboratory
	Brookhaven LINAC Isotope Producer Brookhaven National Laboratory
Facilities not capable of steady-state neutron production	Sandia Pulse Reactor II and III Sandia National Laboratory
	Transient Reactor Test Facility Argonne National Laboratory–West
	Zero Power Physics Reactor Idaho National Engineering and Environmental Laboratory
	Power Burst Facility Idaho National Engineering and Environmental Laboratory
	Intense Pulsed Neutron Source Argonne National Laboratory
	Flash X-Ray Facility Lawrence Livermore National Laboratory
Facilities with insufficient power to sustain adequate steady-state neutron production	Brookhaven Medical Research Reactor Brookhaven National Laboratory
	Los Alamos Critical Assembly Facility Los Alamos National Laboratory
	General Atomics Training, Research and Isotope Production Reactors
	University Small Research Reactors
	Booster Applications Facility Brookhaven National Laboratory
	Cyclotron Facility Brookhaven National Laboratory

**Table 2-4 Irradiation Facilities Considered but Dismissed from Further Evaluation (Continued)**

Facilities unable to produce a constant, reliable source of neutrons due to dependency on the operating schedules of their primary missions	Los Alamos Neutron Science Center Linear Accelerator Isotope Production Facility Los Alamos National Laboratory
	Brookhaven LINAC Isotope Producer Brookhaven National Laboratory
Facilities that are under construction with capacity fully dedicated to other planned missions	Dual Axis Radiographic Hydrodynamic Test Facility Los Alamos National Laboratory
	Spallation Neutron Source Oak Ridge National Laboratory
Facilities that have been permanently shut down	High Flux Beam Reactor Brookhaven National Laboratory
	Tower Shielding Facility Oak Ridge National Laboratory
	Oak Ridge Electron Linear Accelerator Oak Ridge National Laboratory
	Cyclotron Facility Oak Ridge National Laboratory

Source: DOE 2000a.

Two of these facilities, the Brookhaven LINAC Isotope Producer and the Los Alamos Neutron Science Center Linear Accelerator Isotope Production Facility, were identified in this NI PEIS Notice of Intent as existing facilities that could potentially support the proposed nuclear infrastructure missions. Although initially considered, these facilities were dismissed from further consideration because DOE determined that neither facility is capable of producing a constant, reliable source of neutrons due to dependency on the operating schedule of each facility's primary mission. In addition, existing capacity at the Brookhaven LINAC is now dedicated to other missions.

Two existing operating DOE facilities, ATR and HFIR, were evaluated as components of Alternative 2, Use Only Existing Operational Facilities. These two facilities currently provide isotope production capability and were examined for their ability to meet the isotope production and nuclear research and development requirements of the proposed expanded missions. In addition, DOE considered whether production from ATR and HFIR could be enhanced by increasing power levels at the reactors or through other modifications to the facilities. While some growth is possible in production at these two facilities, it would only be sufficient to meet the needs for 5 to 10 years based on the growth projections discussed in Section 1.2.1. Further growth could only be enabled by increasing reactor power levels. At ATR, this option is precluded by the current operating requirements for priority DOE Office of Naval Reactors missions. The power level at HFIR is already at 100 percent of Authorization Basis (85 megawatts), and modification of this Authorization Basis would be required to increase to full-design power (100 megawatts). At HFIR, this option is precluded by the extended facility outage required to implement the modification required to increase the authorized power level to 100 megawatts. This extended outage would have significant impacts on DOE Office of Science missions performed at this facility. Therefore, increasing power levels is not a reasonable alternative at either ATR or HFIR. DOE has not identified any other reasonable options to enhance the capabilities of these reactors.

DOE also evaluated its ability to meet increased medical and industrial isotope production and nuclear research and development needs by using existing neutron-producing accelerators. DOE concluded that using these facilities to meet the proposed action would adversely impact or replace their existing missions. Because of DOE's stated commitment not to displace current DOE missions at these facilities as a consequence of this proposed action, DOE dismissed from further consideration both the use of existing accelerators and increases in the power levels at HFIR or ATR as reasonable alternatives for the proposed missions.

Modification of CLWRs to enable online insertion and retrieval of targets for the medical and industrial isotope production missions was evaluated and dismissed as a reasonable alternative. This decision was made because the required facility modifications would be significant and would include penetrations into the reactor vessel and, potentially, the containment vessel. Additional facility modifications would be required to enable loading of the targets into a shielded cask for transport to a processing facility. Performing these facility modifications would require an extended refueling outage (with a resulting loss of power generation revenue to the CLWR owner) and could potentially extend subsequent maintenance or refueling outages to inspect, test and maintain the insertion and retrieval system, reactor vessel penetrations, and potential containment vessel penetrations. In the event that CLWRs are used for medical isotope production, the selection of isotopes to be produced would be limited to those with relatively long half-lives because there are no CLWR sites with facilities for processing irradiated targets. The targets would have to be shipped to a DOE site or to a commercial medical isotope vendor facility for processing and subsequent distribution to users. CLWRs were also considered for the proposed DOE nuclear research and development missions. CLWRs will continue to support the commercial industry research and development activities by providing a test bed for industry sponsored lead test assemblies and other related research. CLWRs can not meet most of the requirements for supporting the DOE nuclear research and development missions and were therefore dismissed as a reasonable alternative for supporting these missions.

CANDU reactors, operating in Canada, were considered for supplying irradiation services for the plutonium-238 production mission. (Note: Canada is currently the major supplier of medical radioisotopes used in the United States.) Since use of the CANDU reactors does not meet the programmatic issue being addressed in this NI PEIS, that is, the enhancement of the United States infrastructure to support the proposed missions, the CANDU reactors were considered but were dismissed as a reasonable alternative. However, the environmental impacts associated with transporting the nonirradiated and irradiated neptunium-237 targets between the CANDU reactors and the target fabrication and processing facilities in the United States are bound by the evaluations presented in this NI PEIS for the CLWR options of Alternative 2, Use Only Existing Operational Facilities.

Some facilities listed in Table 2–4 that do not have the capacity to support the proposed missions without impacting existing missions, have some existing medical or industrial isotope production or nuclear research and development missions. These facilities will continue to support their existing missions at current levels.

### **2.6.2 Processing Facilities Dismissed**

Numerous existing U.S. processing hot cell facilities possess the capabilities and capacity to support the proposed missions. Given this general availability, only existing processing facilities that are collocated at DOE's candidate irradiation facility sites (i.e., ORNL, INEEL, and Hanford) were evaluated in this NI PEIS. Although multiple processing facilities exist at each of these sites, only the most suitable facilities in terms of capability, capacity, and availability were given further consideration. The processing facilities that were dismissed from consideration are listed in **Table 2–5**.

Based on public comments on the scope of the *Plutonium-238 Production EIS*, the H-Canyon and HB-Line facilities at SRS that previously performed the processing for the plutonium-238 production mission were reconsidered as potential processing facilities for the proposed plutonium-238 production mission even though the facilities are not collocated with a proposed irradiation facility. After reviewing the plutonium-238 production target fabrication and processing requirements, the capabilities and capacities of the facilities, and the modifications and resources required to support the plutonium-238 production mission, use of the H-Canyon and HB-Line facilities was dismissed as a reasonable alternative because:

**Table 2–5 Processing Facilities Considered but Dismissed from Further Consideration**

<b>Location</b>	<b>Facility</b>
Argonne National Laboratory	Irradiated Materials Facility
	Alpha-Gamma Hot Cell Facility
	Building 205
Argonne National Laboratory–West	Hot Fuel Examination Facility
	Analytical Laboratory
	Fuel Conditioning Facility
Brookhaven National Laboratory	Target Processing Laboratory
	Metallurgical Evaluation Laboratory
	High Intensity Radiation Development Laboratory
Hanford Site	222-S Facility
	Postirradiation Testing Laboratory
	Shielded Material Facility
Idaho National Engineering and Environmental Laboratory	Test Area North
	Hot Shop and Hot Cell Facilities
	Remote Analytical Laboratory
	Fuel Processing Facility
Los Alamos National Laboratory	Chemistry and Metallurgical Research Building
	Technical Area–48
Oak Ridge National Laboratory	Radioactive Materials Analytical Laboratory
	Building 4501
	Irradiated Materials Examination and Testing Facility
	Radioisotope Development Laboratory
	Irradiated Fuels Examination Laboratory
Sandia National Laboratories	Hot Cell Facility
Savannah River Site	Defense Waste Processing Facility
	High-level cells
	Intermediate-level cells
	Californium shipping/receiving facility
	Californium processing facility

**Source:** DOE 2000a.

1. DOE plans to shut down these facilities following completion of their current missions to stabilize and prepare for disposition of Cold War legacy nuclear materials and certain spent nuclear fuel, and a determination that a new nonchemical processing technology is capable of preparing aluminum-clad research reactor spent nuclear fuel for ultimate disposition.
2. The cost to extend the operating lives of these facilities to support plutonium-238 production for the proposed 35-year evaluation period would be approximately one order of magnitude higher than the costs associated with the processing facilities evaluated in this NI PEIS.

A commentator also proposed using the H-Canyon and HB-Line for a short campaign to produce all of the required plutonium-238. Based on prior production rates, it would take approximately 7 years to produce 175 kilograms (385 pounds) of plutonium-238, the total plutonium-238 production goal. The target fabrication and irradiation requirements to support this processing campaign to produce 25 kilograms (55 pounds) per year of plutonium-238 would be significant but feasible. The irradiation requirements could be supported by operating five CLWRs or operating FFTF at the 400-megawatt power level. However, a concern about the short campaign option is that the plutonium-238 would be stored a long time before use and because of natural

decay may not meet the specification requirements when finally needed. This alternative was dismissed because of the uncertainty that over time the plutonium-238 produced may not meet the required specification for NASA missions.

## **2.7 SUMMARY OF ENVIRONMENTAL IMPACTS AND SCHEDULES**

The following sections summarize the environmental impacts and schedules associated with the alternatives and options and compares the impacts among the alternatives described in Sections 4.2 through 4.7. Chapter 4 shows construction impacts that would result from implementation of Alternative 3 and 4, as well as operational impacts for all of the alternatives. For the purposes of summarizing the impacts, construction and operational impacts are summed in the tables. Section 2.7.1 discusses the impacts of the options under each alternative and compares the environmental impacts and risks among the alternatives. Section 2.7.2 summarizes the implementation schedules for each alternative.

Section 2.7.1 provides baseline environmental data at potential sites for reactors and their associated support facilities and summarizes the incremental environmental effects that would result from implementation of the alternatives. Baseline conditions at the three DOE sites assessed in this NI PEIS (Oak Ridge Reservation, INEEL, and Hanford), as well as an existing CLWR, include present and reasonably foreseeable future actions at each site. Since baseline data for certain irradiation facilities were not available, sitewide data were used to quantify baseline conditions for the assessment of the environmental impacts of proposed actions at each site. Baseline impacts include current operations of the existing reactors and fabrication and processing facilities that are included in the alternatives. Incremental impacts (those additional impacts which would be due to implementation of the alternatives) are added to the baseline impacts to obtain total impacts. Sitewide data set forth in the No Action Alternative define the baseline conditions used in the analysis of other action alternatives for each site and are the data upon which incremental values were added to determine overall impacts. The baseline for transportation impacts on human health and safety was selected as Option 1 of the No Action Alternative (no health or safety impacts).

Numerical values are assigned to environmental impacts that include radiological and nonradiological risks to the public and workers at the candidate sites and along representative transportation routes, potential quantities of waste generated, and potential quantities of spent nuclear fuel generated. These numerical values reflect the degree to which the proposed activities would incrementally increase the environmental impacts of current activities and operations at the candidate sites. It should be noted that most of the options being considered under the various alternatives involve the use of more than one site, so the numerical values presented are the sums of the values for all of the relevant sites or transportation routes. There are two exceptions—the health risks to the maximally exposed offsite individual and the noninvolved worker. For these two exceptions, the numerical value presented is the maximum value among all relevant sites.

### **2.7.1 Summary of Environmental Impacts**

#### **2.7.1.1 Environmental Impacts Relevant to NI PEIS Options**

##### **2.7.1.1.1 Options Under the No Action Alternative**

A comparison of the environmental impacts relevant to the four options under the No Action Alternative is presented in **Table 2–6**. The environmental impacts associated with importing 40 kilograms of plutonium-238 from Russia (relevant to all four options under the No Action Alternative) are addressed in other NEPA documents (DOE 1993) and are incorporated by reference in Section 4.2.1.1. Options 2, 3, and 4, would involve transporting neptunium-237 from SRS to storage facilities at another site, as well as storage of the

**Table 2–6 Summary of Impacts Under the No Action Alternative**

	Option 1			Option 2		Option 3		Option 4	
<b>FFTF in standby</b>	Yes			Yes		Yes		Yes	
<b>Neptunium-237 oxide storage</b>	NA			REDC		CPP-651		FMEF	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total	Increment	Total
<b>Land developed/disturbed (hectares)</b>	18,300	0	18,300	0	18,300	0	18,300	0	18,300
<b>Visual resources</b>	NA	NI	NI	NI	NI	NI	NI	NI	NI
<b>Noise</b>	NA	NI	NI	NI	NI	NI	NI	NI	NI
<b>Air quality (criteria pollutants)</b>	NE	NI	NE	NI	NE	NI	NE	NI	NE
<b>Air quality (toxic pollutants)</b>	NE	NI	NE	NI	NE	NI	NE	NI	NE
<b>Water use (millions of liters per year)</b>	171,000	0	171,000	0	171,000	0	171,000	0	171,000
<b>Water quality</b>	NA	NI	NI	NI	NI	NI	NI	NI	NI
<b>Geology and soils</b>	NA	NI	NI	NI	NI	NI	NI	NI	NI
<b>Ecological resources</b>	NA	NI	NI	NI	NI	NI	NI	NI	NI
<b>Cultural and paleontological resources</b>	NA	NI	NI	NI	NI	NI	NI	NI	NI
<b>Socioeconomics (site employment)</b>	28,000	0	28,000	0	28,000	0	28,000	0	28,000
<b>Environmental justice</b>	NA	NI	NI	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety</b>									
Latent cancer fatality risk from normal operation (35 years)									
Maximally exposed offsite individual	6.3×10 <sup>-5</sup>	0	6.3×10 <sup>-5</sup>	2.3×10 <sup>-9</sup>	6.3×10 <sup>-5</sup>	2.3×10 <sup>-9</sup>	6.3×10 <sup>-5</sup>	2.3×10 <sup>-9</sup>	6.3×10 <sup>-5</sup>
Population	1.2	0	1.2	4.9×10 <sup>-4</sup>	1.2	4.9×10 <sup>-4</sup>	1.2	4.9×10 <sup>-4</sup>	1.2
Workforce	18.0	0.0097	18.0	0.0097	18.0	0.0097	18.0	0.0097	18.0
Hazardous chemical risk increase from normal operation									
Cancer risk	NA	0	0	0	0	0	0	0	0
Hazard Index	NA	0	0	0	0	0	0	0	0
Latent cancer fatality risk from accidents (35 years)									
Maximally exposed offsite individual	5.7×10 <sup>-5</sup>	0	5.7×10 <sup>-5</sup>	0	5.7×10 <sup>-5</sup>	0	5.7×10 <sup>-5</sup>	0	5.7×10 <sup>-5</sup>
Population	0.17	0	0.17	0	0.17	0	0.17	0	0.17
Noninvolved worker	2.4×10 <sup>-5</sup>	0	2.4×10 <sup>-5</sup>	0	2.4×10 <sup>-5</sup>	0	2.4×10 <sup>-5</sup>	0	2.4×10 <sup>-5</sup>
<b>Waste generation (35 years)</b>									
Transuranic waste (m <sup>3</sup> )	78,000	0	78,000	0	78,000	0	78,000	0	78,000
Low-level radioactive waste (m <sup>3</sup> )	590,000	0	590,000	<10	590,000	<10	590,000	<10	590,000
Mixed low-level radioactive waste (m <sup>3</sup> )	91,000	0	91,000	0	91,000	0	91,000	0	91,000
Hazardous waste (m <sup>3</sup> )	27,000	0	27,000	0	27,000	0	27,000	0	27,000
Nonhazardous waste (m <sup>3</sup> )	3.5×10 <sup>7</sup>	0	3.5×10 <sup>7</sup>	0	3.5×10 <sup>7</sup>	0	3.5×10 <sup>7</sup>	0	3.5×10 <sup>7</sup>
<b>Spent fuel generation (metric tons per year)</b>	NA <sup>b</sup>	0	0	0	0	0	0	0	0
<b>Occupational and public health and safety associated with transportation</b>									
Intersite transportation distance (million km)	0	0.11	0.11	0.17	0.17	0.48	0.48	0.55	0.55
Latent cancer fatality risk increase from incident-free transportation									
Public	0	0.010	0.010	0.013	0.013	0.026	0.026	0.029	0.029
Workers	0	0.0046	0.0046	0.0048	0.0048	0.0058	0.0058	0.0060	0.0060
Nonradiological fatalities risk to public from incident-free operations	0	0.00047	0.00047	0.00097	0.00097	0.0022	0.0022	0.0023	0.0023

**Table 2–6 Summary of Impacts Under the No Action Alternative (Continued)**

	Option 1			Option 2		Option 3		Option 4	
<b>FFTF in standby</b>	Yes			Yes		Yes		Yes	
<b>Neptunium-237 oxide storage</b>	NA			REDC		CPP-651		FMEF	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total	Increment	Total
Latent cancer fatality risk increase to public from accident conditions	0	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044
Nonradiological fatalities risk to public from accident conditions	0	0.014	0.014	0.014	0.014	0.016	0.016	0.016	0.016

a. Baseline impacts include contributions from the sites with currently existing candidate irradiation facilities. Baseline impacts for new candidate irradiation facilities were assumed to be zero.

b. 2,700 metric tons of DOE spent nuclear fuel currently exist.

**Key:** kg, kilogram; km, kilometer; m<sup>3</sup>, cubic meters; NA, not applicable; NE, no exceedance of air quality standards; NI, no or negligible impact.

neptunium-237 in these facilities for 35 years. As indicated in Table 2–6, under the No Action Alternative direct radiation exposure or effluent release would result in a small increase in radiological risk among transportation workers, the public along representative transportation routes, and to workers and the public at the storage sites. As no new facilities would be constructed under any option for the No Action Alternative, there would be no additional land disturbance or associated impacts on visual resources, geology and soils, ecological resources, or cultural and paleontological resources.

Under all options for the No Action Alternative, no additional impact on water resources is expected in association with neptunium-237 storage. Projected annual water usage for 35 years of storage is shown in Table 2–6.

#### **2.7.1.1.2 Options Under Alternative 1—Restart FFTF**

**Table 2–7** compares the six options under Alternative 1. The most significant difference between Options 1, 2, and 3 and Options 4, 5, and 6 is the configuration of the FFTF core, i.e., whether the reactor would operate with mixed oxide or highly enriched uranium fuel. This difference would have little effect on the environmental impacts associated with activities such as FFTF operation or target fabrication and processing at the candidate sites. Options 1 and 4, 2 and 5, and 3 and 6 are paired together in Table 2–7. The choice of mixed oxide or highly enriched uranium fuel, however, would have a small impact associated with transporting either fuel type prior to placement in FFTF (see Chapter 4).

Irradiation facilities (FFTF at Hanford) and the fabrication and processing facilities (FMEF or the RPL/Building 306–E at Hanford, REDC at ORNL, or FDPF or CPP–651 at INEEL) proposed under Alternative 1 are all existing facilities that would require only internal modifications or minor external modifications (e.g., the stack at FMEF) to fulfill their role. As indicated in Table 2–7, the impacts to environmental resources that are usually associated with construction activities are minimal for all of the Alternative 1 options.

As no new facilities would be constructed under any option for this alternative, there would be no additional land disturbance or associated impacts on visual resources, water quality, geology and soils, ecological resources, or cultural and paleontological resources.

FFTF restart under Alternative 1 would result in additional water use under all options, with the highest usage under Option 3 or 6 with FFTF restart coupled with target fabrication and processing in FMEF. For Options 3 and 6, water use in the 400 Area of Hanford would increase by about 79 million liters (21 million gallons) per

**Table 2–7 Summary of Impacts Under Alternative 1—Restart FFTF**

	Option 1 or 4			Option 2 or 5		Option 3 or 6	
<b>Irradiation facility</b>	FFTF			FFTF		FFTF	
<b>Fabrication and processing facility for plutonium-238</b>	REDC			FDPF/CPP–651		FMEF	
<b>Fabrication and processing facility for medical and industrial isotope targets</b>	RPL/306–E			RPL/306–E		FMEF	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
<b>Land developed/disturbed (hectares)</b>	18,300	0	18,300	0	18,300	0	18,300
<b>Visual resources</b>	NA	NI	NI	NI	NI	NI	NI
<b>Noise</b>	NA	NI	NI	NI	NI	NI	NI
<b>Air quality (criteria pollutants)</b>	NE	NI	NE	NI	NE	NI	NE
<b>Air quality (toxic pollutants)</b>	NE	NI	NE	NI	NE	NI	NE
<b>Water use (millions of liters per year)</b>	171,000	61	171,061	61	171,061	79	171,079
<b>Water quality</b>	NA	NI	NI	NI	NI	NI	NI
<b>Geology and soils</b>	NA	NI	NI	NI	NI	NI	NI
<b>Ecological resources</b>	NA	NI	NI	NI	NI	NI	NI
<b>Cultural and paleontological resources</b>	NA	NI	NI	NI	NI	NI	NI
<b>Socioeconomics (site employment)</b>	28,000	97	28,097	80	28,080	130	28,130
<b>Environmental justice</b>	NA	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety</b>							
Latent cancer fatality risk from normal operation (35 years)							
Maximally exposed offsite individual	$6.7 \times 10^{-5}$	$9.5 \times 10^{-8}$	$6.7 \times 10^{-5}$	$9.5 \times 10^{-8}$	$6.7 \times 10^{-5}$	$1.2 \times 10^{-8}$	$6.7 \times 10^{-5}$
Population	1.2	0.0045	1.2	0.0045	1.2	0.0023	1.2
Workforce	18.0	0.395	18.4	0.395	18.4	0.400	18.4
Hazardous chemical risk increase from normal operation							
Cancer risk	NA	$2.6 \times 10^{-7}$	$2.6 \times 10^{-7}$	$1.3 \times 10^{-7}$	$1.3 \times 10^{-7}$	$4.7 \times 10^{-8}$	$4.7 \times 10^{-8}$
Hazard Index	NA	0.00639	0.0064	0.0031	0.0031	0.014	0.014
Latent cancer fatality risk from accidents (35 years)							
Maximally exposed offsite individual	$5.7 \times 10^{-5}$	$3.6 \times 10^{-4}$	$3.6 \times 10^{-4}$	$3.6 \times 10^{-4}$	$3.6 \times 10^{-4}$	$6.9 \times 10^{-6}$	$5.7 \times 10^{-5}$
Population	0.17	0.54	0.71	0.41	0.58	0.21	0.38
Noninvolved worker	$2.4 \times 10^{-5}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.8 \times 10^{-4}$	$3.8 \times 10^{-4}$
<b>Waste generation (35 years)</b>							
Transuranic waste (cubic meters)	78,000	380	78,000	240	78,000	380	78,000
Low-level radioactive waste (cubic meters)	590,000	5,000	595,000	5,100	595,000	5,000	595,000
Mixed low-level radioactive waste (cubic meters)	91,000	320	91,000	320	91,000	320	91,000
Hazardous waste (cubic meters)	27,000	680	28,000	680	28,000	670	28,000
Nonhazardous waste (cubic meters)	$3.5 \times 10^7$	844,000	$3.6 \times 10^7$	844,000	$3.6 \times 10^7$	$1.5 \times 10^6$	$3.6 \times 10^7$
<b>Spent fuel generation</b>	0 <sup>b</sup>	0.46	0.46	0.46	0.46	0.46	0.46

**Table 2–7 Summary of Impacts Under Alternative 1—Restart FFTF (Continued)**

	Option 1 or 4			Option 2 or 5		Option 3 or 6	
<b>Irradiation facility</b>	FFTF			FFTF		FFTF	
<b>Fabrication and processing facility for plutonium-238</b>	REDC			FDPF/CPP–651		FMEF	
<b>Fabrication and processing facility for medical and industrial isotope targets</b>	RPL/306–E			RPL/306–E		FMEF	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
<b>Occupational and public health and safety associated with transportation</b>							
Intersite transportation distance (million kilometers)	0	8.1	8.1	6.4	6.4	5.9	5.9
Latent cancer fatality risk increase from incident-free transportation							
Public	0	0.15	0.15	0.056	0.056	0.025	0.025
Workers	0	0.013	0.013	0.009	0.009	0.0083	0.0083
Nonradiological fatalities risk to public from incident-free operations	0	0.03	0.03	0.025	0.025	0.024	0.024
Latent cancer fatality risk increase to public from accident conditions	0	0.53	0.53	0.53	0.53	0.53	0.53
Nonradiological fatalities risk to public from accident conditions	0	0.19	0.19	0.13	0.13	0.12	0.12

a. Baseline impacts include contributions from the sites with currently existing candidate irradiation facilities. Baseline impacts for new candidate irradiation facilities were assumed to be zero.

b. 2,700 metric tons of DOE spent nuclear fuel currently exist.

**Key:** NA, not applicable; NE, no exceedance of air quality standards; NI, no or negligible impact.

year, primarily to support the increased process cooling needs of FFTF and FMEF (Table 2–7). However, the impact on resource availability and water quality is expected to be minor.

Restart of FFTF and the additional missions at the candidate facilities would require increasing the workforce at these facilities by approximately 100 workers. As this increase would not measurably impact regional economic areas at the candidate sites, the socioeconomic impacts of the options under Alternative 1 would be minimal.

As shown in the Table 2–7, implementation of this alternative would not be expected to have a significant impact on air quality. Public hazard indices for all of the options would be less than 0.002. Cancer risk probabilities from toxic chemical inhalation would be less than  $3 \times 10^{-7}$  for all options under this alternative.

As shown in Table 2–7, normal operations that would be conducted at FFTF and the associated support facilities under this alternative would pose little incremental radiological risk to the public or uninvolved workers. No latent cancer fatalities would be expected to result from incident-free transportation.

Accidents at the support facilities and along representative transportation routes were found to pose the largest radiological risks to the public and workers. Under Options 1 and 4, the expected number of latent cancer fatalities due to an accident with radiological consequences would be approximately 0.5 among the public at risk surrounding Hanford or ORNL. It is the largest radiological risk among all of the alternatives. As shown in Chapter 4 and Appendix I, it is largely driven by the risks associated with a beyond-design-basis earthquake at REDC and a glovebox explosion at RPL. For all options under Alternative 1, accidents at FFTF were found

to pose a small risk to the public relative to the risks attributed to accidents at the fabrication and processing facilities. Similar remarks apply to Options 2, 3, 5, and 6 under Alternative 1.

For all of the options under Alternative 1, transportation accidents having radiological consequences would be expected to result in approximately 0.5 latent cancer fatalities. As described in Chapter 4 and Appendix J, radiological transportation risks are driven by aircraft accidents that could occur during airborne transportation of medical and industrial isotopes. Radiological risks associated with ground transportation were found to be five orders of magnitude less than those associated with air transportation of radioactive isotopes.

For all the options under Alternative 1, it is DOE's intent that waste generated from the restart and operation of FFTF be managed independent of the existing Hanford site waste management infrastructure by using commercially available facilities for all waste treatment and disposal activities. DOE has developed a draft *Waste Minimization and Management Plan for FFTF* to incorporate pollution prevention and waste minimization practices in its consideration of the future of FFTF (DOE 2000b). If a decision were made to restart FFTF, this plan would be used to ensure that optimum opportunities are provided for characterizing potential waste streams, identifying source reduction and recycling strategies, evaluating disposition options, developing sustainable designs, and implementing effective management strategies. This plan identifies DOE's preferred options for management, treatment, and/or disposition of all waste streams related to the restart and operation of FFTF. These preferred options primarily use commercial waste handling and disposal facilities. Although it is DOE's intent to use commercial waste handling and disposal facilities, the Hanford waste management infrastructure is analyzed in this NI PEIS as a reasonable alternative for the management of wastes resulting from FFTF restart and operation in case commercial disposal is not practicable at the time of restart and operation.

#### **2.7.1.1.3 Options Under Alternative 2—Use Only Existing Operational Facilities**

The environmental impacts of the nine options under Alternative 2 are compared in **Tables 2–8** through **2–10**. Table 2–8 summarizes environmental effects that would be expected to occur if ATR were selected as the irradiation facility. Table 2–9 summarizes environmental effects that would be expected to occur if a CLWR (yet to be selected) were selected as the irradiation facility, and Table 2–10 gives similar data for options for which ATR and HFIR were selected as irradiation facilities. The proposed irradiation facilities (either ATR, CLWR, or HFIR) and fabrication/processing facilities (either FMEF, REDC, FDPF, or CPP–651) are existing facilities that would need only internal modifications or minor external modifications (the stack at FMEF) to fulfill their role. Impacts to environmental resources that are associated with construction activities are small for all of the Alternative 2 options (Chapter 4).

Continued operation of existing reactor facilities would not increase the necessary workforce, but the additional missions at the proposed fabrication and processing facilities would require an increase in the workforce of less than 100 workers. However, FFTF deactivation would result in a reduction of 300 workers. These changes would not measurably impact regional economic areas at the candidate sites. Therefore, the socioeconomic impacts of all of the options under Alternative 2 would be minimal.

As shown in the Table 2–8 through 2–10, implementation of this alternative would not be expected to have a significant impact on air quality. Public hazard indices for all of the options would be less than 0.007. The risk of cancer resulting from chemical inhalation would be less than  $3 \times 10^{-7}$  for all options under this alternative (Chapter 4).

As no new facilities would be constructed under any option for this alternative, there would be no additional land disturbance or associated impacts on visual resources, water quality, geology and soils, ecological resources, or cultural and paleontological resources.

**Table 2–8 Summary of ATR Impacts Under Alternative 2—Use Only Existing Operational Facilities**

		Option 1		Option 2		Option 3	
Irradiation facility		ATR		ATR		ATR	
Fabrication and processing facility for plutonium-238		REDC		FDPF/CPP–651		FMEF	
Fabrication and processing facility for medical and industrial isotope targets		NA		NA		NA	
FFTF deactivation		Yes		Yes		Yes	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
Land developed/disturbed (hectares)	18,300	0	18,300	0	18,300	0	18,300
Visual resources	NA	NI	NI	NI	NI	NI	NI
Noise	NA	NI	NI	NI	NI	NI	NI
Air quality (criteria pollutants)	NE	NI	NE	NI	NE	NI	NE
Air quality (toxic pollutants)	NE	NI	NE	NI	NE	NI	NE
Water use <sup>b</sup> (millions of liters per year)	171,000	-197	170,803	-197	170,803	-178	170,822
Water quality	NA	NI	NI	NI	NI	NI	NI
Geology and soils	NA	NI	NI	NI	NI	NI	NI
Ecological resources	NA	NI	NI	NI	NI	NI	NI
Cultural and paleontological resources	NA	NI	NI	NI	NI	NI	NI
Socioeconomics <sup>c</sup> (site employment)	28,000	-259	27,741	-276	27,724	-238	27,762
Environmental justice	NA	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety</b>							
Latent cancer fatality risk from normal operation (35 years)							
Maximally exposed offsite individual	$6.7 \times 10^{-5}$	$1.3 \times 10^{-10}$	$6.7 \times 10^{-5}$	$1.3 \times 10^{-10}$	$6.7 \times 10^{-5}$	$1.3 \times 10^{-10}$	$6.7 \times 10^{-5}$
Population	1.2	$2 \times 10^{-5}$	1.2	$1.8 \times 10^{-5}$	1.2	$1.9 \times 10^{-5}$	1.2
Workforce	18.0	0.31	18.3	0.31	18.3	0.31	18.3
Hazardous chemical risk increase from normal operation							
Cancer risk	NA	$2.6 \times 10^{-7}$	$2.6 \times 10^{-7}$	$1.3 \times 10^{-7}$	$1.3 \times 10^{-7}$	$4.7 \times 10^{-7}$	$4.7 \times 10^{-7}$
Hazard Index	NA	0.0064	0.0064	0.0031	0.0031	0.011	0.011
Latent cancer fatality risk from accidents (35 years)							
Maximally exposed offsite individual	$5.7 \times 10^{-5}$	$5.7 \times 10^{-5}$	$5.7 \times 10^{-5}$	$1.5 \times 10^{-5}$	$5.7 \times 10^{-5}$	$2.9 \times 10^{-6}$	$5.7 \times 10^{-5}$
Population	0.17	0.16	0.33	0.030	0.20	0.11	0.28
Noninvolved worker	$2.4 \times 10^{-5}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$
<b>Waste generation (35 years)</b>							
Transuranic waste (cubic meters)	78,000	380	78,000	240	78,000	380	78,000
Low-level radioactive waste (cubic meters)	590,000	2,100	592,000	2,300	592,000	2,100	592,000
Mixed low-level radioactive waste (cubic meters)	91,000	<180	91,000	<180	91,000	<180	91,000
Hazardous waste (cubic meters)	27,000	3,100	30,000	3,100	30,000	3,100	30,000

**Table 2–8 Summary of ATR Impacts Under Alternative 2—Use Only Existing Operational Facilities (Continued)**

		Option 1		Option 2		Option 3	
Irradiation facility		ATR		ATR		ATR	
Fabrication and processing facility for plutonium-238		REDC		FDPF/CPP–651		FMEF	
Fabrication and processing facility for medical and industrial isotope targets		NA		NA		NA	
FFTF deactivation		Yes		Yes		Yes	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
Nonhazardous waste (cubic meters)	3.5×10 <sup>7</sup>	6,000	3.5×10 <sup>7</sup>	6,000	3.5×10 <sup>7</sup>	660,000	3.6×10 <sup>7</sup>
Spent fuel generation (metric tons per year)	NA <sup>d</sup>	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety associated with transportation</b>							
Intersite transportation distance (million kilometers)	0	2.2	2.2	0.43	0.43	1.2	1.2
Latent cancer fatality risk increase from incident-free transportation							
Public	0	0.12	0.12	0.016	0.016	0.055	0.055
Workers	0	0.005	0.005	0.0014	0.0014	0.0031	0.0031
Nonradiological fatalities risk to public from incident-free operations	0	0.0068	0.0068	0.0019	0.0019	0.0027	0.0027
Latent cancer fatality risk increase to public from accident conditions	0	4.4×10 <sup>-5</sup>	4.4×10 <sup>-5</sup>	2.1×10 <sup>-5</sup>	2.1×10 <sup>-5</sup>	3.0×10 <sup>-5</sup>	3.0×10 <sup>-5</sup>
Nonradiological fatalities risk to public from accident conditions	0	0.060	0.060	0.0017	0.0017	0.019	0.019

- a. Baseline impacts include contributions from the sites with currently existing candidate irradiation facilities. Baseline impacts for new candidate irradiation facilities were assumed to be zero.
- b. Deactivation of FFTF results in a net decrease from the baseline of 197 million liters per year.
- c. Deactivation of FFTF results in a net decrease from the baseline of 300 site employees.
- d. 2,700 metric tons of DOE spent nuclear fuel currently exist.
- Key:** NA, not applicable; NE, no exceedance of air quality standards; NI, no or negligible impact.

**Table 2–9 Summary of CLWR Impacts Under Alternative 2—Use Only Existing Operational Facilities**

		<b>Option 4</b>		<b>Option 5</b>		<b>Option 6</b>	
<b>Irradiation facility</b>		CLWR		CLWR		CLWR	
<b>Fabrication and processing facility for plutonium-238</b>		REDC		FDPF/CPP–651		FMEF	
<b>Fabrication and processing facility for medical and industrial isotope targets</b>		NA		NA		NA	
<b>FFTF deactivation</b>		Yes		Yes		Yes	
	<b>Baseline<sup>a</sup></b>	<b>Increment</b>	<b>Total</b>	<b>Increment</b>	<b>Total</b>	<b>Increment</b>	<b>Total</b>
<b>Land developed/disturbed (hectares)</b>	18,300	0	18,300	0	18,300	0	18,300
<b>Visual resources</b>	NA	NI	NI	NI	NI	NI	NI
<b>Noise</b>	NA	NI	NI	NI	NI	NI	NI
<b>Air quality (criteria pollutants)</b>	NE	NI	NE	NI	NE	NI	NE
<b>Air quality (toxic pollutants)</b>	NE	NI	NE	NI	NE	NI	NE
<b>Water use<sup>b</sup> (millions of liters per year)</b>	171,000	-197	170,803	-197	170,803	-178	170,822
<b>Water quality</b>	NA	NI	NI	NI	NI	NI	NI
<b>Geology and soils</b>	NA	NI	NI	NI	NI	NI	NI
<b>Ecological resources</b>	NA	NI	NI	NI	NI	NI	NI
<b>Cultural and paleontological resources</b>	NA	NI	NI	NI	NI	NI	NI
<b>Socioeconomics<sup>c</sup> (site employment)</b>	28,000	-259	27,741	-276	27,724	-238	27,762
<b>Environmental justice</b>	NA	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety</b>							
Latent cancer fatality risk from normal operation (35 years)							
Maximally exposed offsite individual	$6.7 \times 10^{-5}$	$1.3 \times 10^{-10}$	$6.7 \times 10^{-5}$	$1.3 \times 10^{-10}$	$6.7 \times 10^{-5}$	$1.3 \times 10^{-10}$	$6.7 \times 10^{-5}$
Population	1.2	$2.0 \times 10^{-5}$	1.2	$1.8 \times 10^{-5}$	1.2	$1.9 \times 10^{-5}$	1.2
Workforce	18.0	0.31	18.3	0.31	18.0	0.31	18.3
Hazardous chemical risk increase from normal operation							
Cancer risk	NA	$2.6 \times 10^{-7}$	$2.6 \times 10^{-7}$	$1.3 \times 10^{-7}$	$1.3 \times 10^{-7}$	$4.7 \times 10^{-8}$	$4.7 \times 10^{-8}$
Hazard Index	NA	0.0064	0.0064	0.0031	0.0031	0.011	0.011
Latent cancer fatality risk from accidents (35 years)							
Maximally exposed offsite individual	$5.7 \times 10^{-5}$	$5.7 \times 10^{-5}$	$5.7 \times 10^{-5}$	$1.5 \times 10^{-6}$	$5.7 \times 10^{-5}$	$2.9 \times 10^{-6}$	$5.7 \times 10^{-5}$
Population	0.17	0.16	0.33	0.0321	0.20	0.12	0.29
Noninvolved worker	$2.4 \times 10^{-5}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$
<b>Waste generation (35 years)</b>							
Transuranic waste (cubic meters)	78,000	380	78,000	240	78,000	380	78,000
Low-level radioactive waste (cubic meters)	590,000	2,100	592,000	2,300	592,000	2,100	582,000
Mixed low-level radioactive waste (cubic meters)	91,000	<180	91,000	<180	91,000	<180	91,000
Hazardous waste (cubic meters)	27,000	3,100	30,000	3,100	30,000	3,100	30,000

**Table 2–9 Summary of CLWR Impacts Under Alternative 2—Use Only Existing Operational Facilities (Continued)**

		Option 4		Option 5		Option 6	
Irradiation facility		CLWR		CLWR		CLWR	
Fabrication and processing facility for plutonium-238		REDC		FDPF/CPP–651		FMEF	
Fabrication and processing facility for medical and industrial isotope targets		NA		NA		NA	
FFTF deactivation		Yes		Yes		Yes	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
Nonhazardous waste (cubic meters)	3.5×10 <sup>7</sup>	6,000	3.5×10 <sup>7</sup>	6,000	3.5×10 <sup>7</sup>	660,000	3.6×10 <sup>7</sup>
Spent fuel generation (metric tons per year)	NA <sup>d</sup>	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety associated with transportation</b>							
Intersite transportation distance (million kilometers)	0	2.7	2.7	3.4	3.4	3.9	3.9
Latent cancer fatality risk increase from incident-free transportation							
Public	0	0.15	0.15	0.19	0.19	0.22	0.22
Workers	0	0.0059	0.0059	0.0078	0.0078	0.0090	0.0090
Nonradiological fatalities risk to public from incident-free operations	0	0.0059	0.0059	0.0079	0.0079	0.0089	0.0089
Latent cancer fatality risk increase to public from accident conditions	0	4.4×10 <sup>-5</sup>	4.4×10 <sup>-5</sup>	2.1×10 <sup>-5</sup>	2.1×10 <sup>-5</sup>	3.0×10 <sup>-5</sup>	3.0×10 <sup>-5</sup>
Nonradiological fatalities risk to public from accident conditions	0	0.075	0.075	0.089	0.089	0.102	0.102

- a. Baseline impacts include contributions from the sites with currently existing candidate irradiation facilities. Baseline impacts for new candidate irradiation facilities were assumed to be zero.
- b. Deactivation of FFTF results in a net decrease from the baseline of 197 million liters per year.
- c. Deactivation of FFTF results in a net decrease from the baseline of 300 site employees.
- d. 2,700 metric tons of DOE spent nuclear fuel currently exist.
- Key:** NA, not applicable; NE, no exceedance of air quality standards; NI, no or negligible impact.

**Table 2–10 Summary of ATR + HFIR Impacts Under Alternative 2—Use Only Existing Operational Facilities**

		Option 7		Option 8		Option 9	
Irradiation facility		ATR + HFIR		ATR + HFIR		ATR + HFIR	
Fabrication and processing facility for plutonium-238		REDC		FDPF/CPP-651		FMEF	
Fabrication and processing facility for medical and industrial isotope targets		NA		NA		NA	
FFTF deactivation		Yes		Yes		Yes	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
Land developed/disturbed (hectares)	18,300	0	18,300	0	18,300	0	18,300
Visual resources	NA	NI	NI	NI	NI	NI	NI
Noise	NA	NI	NI	NI	NI	NI	NI
Air quality (criteria pollutants)	NE	NI	NE	NI	NE	NI	NE
Air quality (toxic pollutants)	NE	NI	NE	NI	NE	NI	NE
Water use <sup>b</sup> (millions of liters per year)	171,000	-197	170,803	-197	170,803	-178	170,822
Water quality	NA	NI	NA	NI	NA	NI	NA
Geology and soils	NA	NI	NA	NI	NA	NI	NA
Ecological resources	NA	NI	NA	NI	NA	NI	NA
Cultural and paleontological resources	NA	NI	NA	NI	NA	NI	NA
Socioeconomics <sup>c</sup> (site employment)	28,000	-259	27,741	-276	27,724	-238	27,762
Environmental justice	NA	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety</b>							
Latent cancer fatality risk from normal operation (35 years)							
Maximally exposed offsite individual	$6.7 \times 10^{-5}$	$1.3 \times 10^{-10}$	$6.7 \times 10^{-5}$	$1.3 \times 10^{-10}$	$6.7 \times 10^{-5}$	$1.3 \times 10^{-10}$	$6.7 \times 10^{-5}$
Population	1.2	$2.0 \times 10^{-5}$	1.2	$1.8 \times 10^{-5}$	1.2	$1.9 \times 10^{-5}$	1.2
Workforce	18.0	0.31	18.3	0.31	18.3	0.31	18.3
Hazardous chemical risk increase from normal operation							
Cancer risk	NA	$2.6 \times 10^{-7}$	$2.6 \times 10^{-7}$	$1.3 \times 10^{-7}$	$1.3 \times 10^{-7}$	$4.7 \times 10^{-8}$	$4.7 \times 10^{-8}$
Hazard Index	NA	0.0064	0.0064	0.0031	0.0031	0.011	0.011
Latent cancer fatality risk from accidents (35 years)							
Maximally exposed offsite individual	$5.7 \times 10^{-5}$	$5.7 \times 10^{-5}$	$5.7 \times 10^{-4}$	$1.5 \times 10^{-5}$	$5.7 \times 10^{-5}$	$2.9 \times 10^{-6}$	$5.7 \times 10^{-5}$
Population	0.17	0.16	0.33	0.03	0.20	0.11	0.28
Noninvolved worker	$2.4 \times 10^{-5}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$
<b>Waste generation (35 years)</b>							
Transuranic waste (cubic meters)	78,000	380	78,000	240	78,000	240	78,000
Low-level radioactive waste (cubic meters)	590,000	2,100	592,000	2,300	592,000	2,100	592,000
Mixed low-level radioactive waste (cubic meters)	91,000	<180	91,000	<180	91,000	<180	91,000
Hazardous waste (cubic meters)	27,000	3,100	30,000	3,100	30,000	3,100	30,000

**Table 2–10 Summary of ATR + HFIR Impacts Under Alternative 2—Use Only Existing Operational Facilities (Continued)**

		Option 7		Option 8		Option 9	
Irradiation facility		ATR + HFIR		ATR + HFIR		ATR + HFIR	
Fabrication and processing facility for plutonium-238		REDC		FDPF/CPP–651		FMEF	
Fabrication and processing facility for medical and industrial isotope targets		NA		NA		NA	
FFTF deactivation		Yes		Yes		Yes	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
Nonhazardous waste (cubic meters)	3.5×10 <sup>7</sup>	6,000	3.5×10 <sup>7</sup>	6,000	3.5×10 <sup>7</sup>	660,000	3.6×10 <sup>7</sup>
Spent fuel generation (metric tons per year)	NA <sup>d</sup>	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety associated with transportation</b>							
Intersite transportation distance (million kilometers)	0	1.8	1.8	1.3	1.3	1.9	1.9
Latent cancer fatality risk increase from incident-free transportation							
Public	0	0.098	0.098	0.064	0.064	0.098	0.098
Workers	0	0.041	0.041	0.0033	0.0033	0.0047	0.0047
Nonradiological fatalities risk to public from incident-free operations	0	0.0056	0.0056	0.0043	0.0043	0.0051	0.0051
Latent cancer fatality risk increase to public from accident conditions	0	4.4×10 <sup>-5</sup>	4.4×10 <sup>-5</sup>	4.4×10 <sup>-5</sup>	4.4×10 <sup>-5</sup>	3.0×10 <sup>-5</sup>	3.0×10 <sup>-5</sup>
Nonradiological fatalities risk to public from accident conditions	0	0.048	0.048	0.025	0.025	0.040	0.040

a. Baseline impacts include contributions from the sites with currently existing candidate irradiation facilities. Baseline impacts for new candidate irradiation facilities were assumed to be zero.

b. Deactivation of FFTF results in a net decrease from the baseline of 197 million liters per year.

c. Deactivation of FFTF results in a net decrease from the baseline of 300 site employees.

d. 2,700 metric tons of DOE spent nuclear fuel currently exist.

**Key:** NA, not applicable; NE, no exceedance of air quality standards; NI, no or negligible impact.

Additional water use by FMEF would occur under Options 3, 6, and 9 of Alternative 2 (Tables 2–8, 2–9, and 2–10). This is associated with target fabrication and processing in FMEF. Groundwater use by FMEF in the 400 Area of Hanford would be expected to increase by approximately 19 million liters (5 million gallons) per year to support process cooling and material processing activities in FMEF as well as to provide for potable and sanitary water needs due to increased staffing. However, as permanent deactivation of FFTF is assumed to occur concurrently under all Alternative 2 options resulting in a decrease in 400 Area groundwater withdrawals by as much as 197 million liters (52 million gallons) annually, the net change would be a decrease in groundwater use of approximately 178 million liters (47 million gallons) per year.

Radiological risks to the public under this alternative are driven by radiological accidents at the fabrication and processing facilities. Air transport of medical and industrial isotopes would continue at the baseline levels established for the No Action Alternative. As a result, the risk associated with transportation accidents would be less than 10<sup>-5</sup> latent cancer fatalities under all options.

#### **2.7.1.1.4 Alternative 3—Construct New Accelerator(s)**

Under Alternative 3, target irradiation would be performed in one or two new accelerators at one or two existing DOE site locations. Plutonium-238 fabrication and processing would be conducted at an existing facility at ORNL, INEEL, or Hanford. Fabrication and processing facilities for other targets would be performed at a new facility at a location yet to be determined. Based on assumptions described in Appendixes E, F, H, and I, estimates of health, safety, and waste generation effects were performed for generic irradiation accelerators, a generic fabrication and processing facility, and the existing fabrication and processing facility for plutonium-238.

As shown in **Table 2–11**, radiological accidents at the sites and along representative transportation routes would be expected to drive the radiological risk to the public. Air transportation of medical and industrial isotopes would be included under this alternative. Thus, the radiological risk to the public due to air transportation accidents that could occur would be approximately 0.5 latent cancer fatality under all options. Expected quantities of generated could be managed by DOE’s existing waste management infrastructure. However, transuranic waste generated under any of the options would not be eligible for disposal at the Waste Isolation Pilot Plant (WIPP). Because nondefense transuranic waste has no current disposition path, approval by DOE Headquarters would be required before such waste could be generated.

Construction of a new high-energy accelerator, a new low-energy accelerator, and an optional support facility at a generic DOE site would disturb an estimated 27 hectares (66 acres) of land in total, should all three facilities be built (Table 2–11). However, it is unlikely that all of the land disturbed for construction of the facilities would be permanently converted to developed use (i.e., impervious surface). Therefore, the totals for “land developed/disturbed” in Table 2–11 would likely be less than shown. Ground disturbance would be the highest for construction of the high-energy accelerator (20.2 hectares [50 acres]), with construction of the low-energy accelerator and support facility disturbing 4 hectares (10 acres) and 2.4 hectares (6 acres), respectively. As associated impacts on visual resources, water quality, geology and soils, ecological resources, and cultural and paleontological resources would be site specific and cannot be assessed at this time, site selection and preconstruction surveys would be conducted to minimize impacts, with appropriate mitigation performed as necessary.

Water use associated with operation of a new high-energy accelerator, a new low-energy accelerator, and an optional support facility over 35 years is estimated to average about 1,917 million liters (506.5 million gallons) per year. Annual operation of the high-energy accelerator would account for about 1,904 million liters (503 million gallons) of this total due to the high demand of cooling tower operation. Depending on the existing supply system or availability of surface or groundwater, it might be necessary to construct a dedicated surface water intake or wells to meet the demands of these facilities, especially the high-energy accelerator. As shown in Table 2–11, the option increments and corresponding totals also reflect a decrease in water use of 197 million liters (52 million gallons) annually due to permanent deactivation of FFTF. Thus, the net increases are presented.

There would be little or no additional land disturbance or associated impacts on visual resources, water use, water quality, geology and soils, ecological resources, or cultural and paleontological resources associated with target fabrication and processing in any of the existing facilities under consideration.

Some of the environmental effects could not be evaluated because they are site-specific (see Table 2–11). If this alternative were selected for implementation, site specific environmental documentation would be provided before implementation would begin.

**Table 2–11 Summary of Impacts Under Alternative 3—Construct New Accelerator(s)**

		Option 1		Option 2		Option 3	
Irradiation facility		New accelerator(s)		New accelerator(s)		New accelerator(s)	
Fabrication and processing facility for plutonium-238		REDC		FDPF/CPP-651		FMEF	
Fabrication and processing facility for medical and industrial isotope targets		New facility (optional)		New facility (optional)		New facility (optional)	
FFTF deactivation		Yes		Yes		Yes	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
Land developed/disturbed (hectares)	18,300	27	18,327	27	18,327	27	18,327
Visual resources	SP	SP	SP	SP	SP	SP	SP
Noise	SP	SP	SP	SP	SP	SP	SP
Air quality (criteria pollutants)	SP	SP	SP	SP	SP	SP	SP
Air quality (toxic pollutants)	SP	SP	SP	SP	SP	SP	SP
Water use (millions of liters per year)	171,000	1,720	172,720	1,720	172,720	1,720	172,720
Water quality	SP	SP	SP	SP	SP	SP	SP
Geology and soils	SP	SP	SP	SP	SP	SP	SP
Ecological resources	SP	SP	SP	SP	SP	SP	SP
Cultural and paleontological resources	SP	SP	SP	SP	SP	SP	SP
Socioeconomics <sup>b</sup> (site employment)	28,000	-34	27,966	-51	27,949	-13	27,987
Environmental justice	NA	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety</b>							
Latent cancer fatality risk from normal operation (35 years)							
Maximally exposed offsite individual	$6.7 \times 10^{-5}$	$6.0 \times 10^{-8}$	$6.7 \times 10^{-5}$	$6.0 \times 10^{-8}$	$6.7 \times 10^{-5}$	$6.0 \times 10^{-8}$	$6.7 \times 10^{-5}$
Population	1.2	0.0035	1.2	0.0035	1.2	0.0035	1.2
Workforce	18.0	1.10	19.1	1.10	19.1	1.10	19.1
Hazardous chemical risk increase from normal operation							
Cancer risk	NA	SP	SP	SP	SP	SP	SP
Hazard Index	NA	SP	SP	SP	SP	SP	SP
Latent cancer fatality risk from accidents (35 years)							
Maximally exposed offsite individual	$5.7 \times 10^{-5}$	$9.25 \times 10^{-5}$	$9.25 \times 10^{-5}$	$1.5 \times 10^{-5}$	$5.7 \times 10^{-5}$	$2.9 \times 10^{-6}$	$5.7 \times 10^{-5}$
Population	0.17	0.22	0.39	0.030	0.20	0.11	0.28
Noninvolved worker	$2.4 \times 10^{-5}$	$4.8 \times 10^{-4}$	$4.8 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$	$3.5 \times 10^{-4}$
<b>Waste generation (35 years)</b>							
Transuranic waste (cubic meters)	78,000	380	78,000	380	78,000	380	78,000
Low-level radioactive waste (cubic meters)	590,000	5,000	595,000	5,200	595,000	5,000	595,000
Mixed low-level radioactive waste (cubic meters)	91,000	430	91,000	430	91,000	430	91,000
Hazardous waste (cubic meters)	27,000	3,200	30,000	3,200	30,000	3,200	30,000
Nonhazardous waste (cubic meters)	$3.5 \times 10^7$	$1.1 \times 10^7$	$4.6 \times 10^7$	$1.1 \times 10^7$	$4.6 \times 10^7$	$1.1 \times 10^7$	$4.6 \times 10^7$

**Table 2–11 Summary of Impacts Under Alternative 3—Construct New Accelerator(s) (Continued)**

		Option 1		Option 2		Option 3	
Irradiation facility		New accelerator(s)		New accelerator(s)		New accelerator(s)	
Fabrication and processing facility for plutonium-238		REDC		FDPF/CPP-651		FMEF	
Fabrication and processing facility for medical and industrial isotope targets		New facility (optional)		New facility (optional)		New facility (optional)	
FFTF deactivation		Yes		Yes		Yes	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
Spent fuel generation (metric tons per year)	NA <sup>c</sup>	NA	NA	NA	NA	NA	NA
<b>Occupational and public health and safety associated with transportation</b>							
Intersite transportation distance (million kilometer)	0	5.7	5.7	6.0	6.0	6.2	6.2
Latent cancer fatality risk increase from incident-free transportation							
Public	0	0.056	0.056	0.069	0.069	0.079	0.079
Workers	0	0.081	0.081	0.0091	0.0091	0.0096	0.0096
Nonradiological fatalities risk to public from incident-free operations	0	0.023	0.023	0.024	0.024	0.024	0.024
Latent cancer fatality risk increase to public from accident conditions	0	0.53	0.53	0.53	0.53	0.53	0.53
Nonradiological fatalities risk to public from accident conditions	0	0.14	0.14	0.14	0.14	0.14	0.14

a. Baseline impacts include contributions from the sites with currently existing candidate irradiation facilities. Baseline impacts for new candidate irradiation facilities were assumed to be zero.

b. Deactivation of FFTF results in a net decrease from the baseline of 300 site employees.

c. 2,700 metric tons of DOE spent nuclear fuel currently exist.

**Key:** NA, not applicable; NI, no or negligible impact; SP, site specific.

#### 2.7.1.1.5 Alternative 4—Construct New Research Reactor

The comparison of the three options under Alternative 4 is presented in **Table 2–12**.

Construction of a research reactor and an optional support facility would disturb an estimated 4 hectares (10 acres) of land in total, should both facilities be built (Table 2–12). However, it is unlikely that all of the land disturbed for construction of the facilities would be permanently converted to developed use (i.e., impervious surface). Therefore, the totals for “land developed/disturbed” in Table 2–12 would likely be less than shown. Ground disturbance would be the highest for construction of the support facility (2.4 hectares [6 acres]), with construction of the research reactor disturbing 1.6 hectares (4 acres). As associated impacts on visual resources, water quality, geology and soils, ecological resources, and cultural and paleontological resources would be site-specific and cannot be assessed at this time, site selection and pre-construction surveys would be conducted to minimize impacts, with appropriate mitigation performed as necessary.

Water use associated with operation of a new research reactor and an optional support facility over 35 years is estimated to average about 818 million liters (216 million gallons) per year. Annual operation of the research reactor would account for about 807 million liters (213.1 million gallons) of this total due to the high demand of cooling tower operation. Depending on the existing supply system or availability of surface or

**Table 2–12 Summary of Impacts Under Alternative 4—Construct New Research Reactor**

		Option 1		Option 2		Option 3	
Irradiation facility		New research reactor		New research reactor		New research reactor	
Fabrication and processing facility for plutonium-238		REDC		FDPF/CPP-651		FMEF	
Fabrication and processing facility for medical and industrial isotope targets		New facility (optional)		New facility (optional)		New facility (optional)	
FFTF deactivation		Yes		Yes		Yes	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
Land developed/disturbed (hectares)	18,300	4	18,304	4	18,304	4	18,304
Visual resources	SP	SP	SP	SP	SP	SP	SP
Noise	SP	SP	SP	SP	SP	SP	SP
Air quality (criteria pollutants)	SP	SP	SP	SP	SP	SP	SP
Air quality (toxic pollutants)	SP	SP	SP	SP	SP	SP	SP
Water use (millions of liters per year)	171,000	621	171,621	621	171,621	621	171,621
Water quality	SP	SP	SP	SP	SP	SP	SP
Geology and soils	SP	SP	SP	SP	SP	SP	SP
Ecological resources	SP	SP	SP	SP	SP	SP	SP
Cultural and paleontological resources	SP	SP	SP	SP	SP	SP	SP
Socioeconomics <sup>b</sup> (site employment)	28,000	-139	27,861	-156	27,844	-118	27,882
Environmental justice	NA	NI	NI	NI	NI	NI	NI
<b>Occupational and public health and safety</b>							
Latent cancer fatality risk from normal operation (35 years)							
Maximally exposed offsite individual	$6.7 \times 10^{-5}$	$4.6 \times 10^{-8}$	$6.7 \times 10^{-5}$	$4.6 \times 10^{-8}$	$6.7 \times 10^{-5}$	$4.6 \times 10^{-8}$	$6.7 \times 10^{-5}$
Population	1.2	0.0025	1.2	0.0025	1.2	0.0025	1.2
Workforce	18.0	0.65	18.7	0.65	18.7	0.65	18.7
Hazardous chemical risk increase from normal operation							
Cancer risk	NA	SP	SP	SP	SP	SP	SP
Hazard Index	NA	SP	SP	SP	SP	SP	SP
Latent cancer fatality risk from accidents (35 years)							
Maximally exposed offsite individual	$5.7 \times 10^{-5}$	$9.0 \times 10^{-5}$	$9.0 \times 10^{-5}$	$4.8 \times 10^{-5}$	$5.7 \times 10^{-5}$	$3.6 \times 10^{-5}$	$5.7 \times 10^{-5}$
Population	0.17	0.21	0.39	0.09	0.26	0.17	0.34
Noninvolved worker	$2.4 \times 10^{-5}$	$4.5 \times 10^{-4}$	$4.5 \times 10^{-4}$	$4.5 \times 10^{-4}$	$4.5 \times 10^{-4}$	$4.5 \times 10^{-4}$	$4.5 \times 10^{-4}$
<b>Waste generation (35 years)</b>							
Transuranic waste (cubic meters)	78,000	380	78,000	240	78,000	380	78,000
Low-level radioactive waste (cubic meters)	590,000	4,800	595,000	4,900	595,000	4,800	595,000
Mixed low-level radioactive waste (cubic meters)	91,000	330	91,000	330	91,000	330	91,000
Hazardous waste (cubic meters)	27,000	3,300	30,000	3,300	30,000	3,300	30,000
Nonhazardous waste (cubic meters)	$3.5 \times 10^7$	$1.0 \times 10^6$	$3.6 \times 10^7$	$1.0 \times 10^6$	$3.6 \times 10^7$	$1.7 \times 10^6$	$3.7 \times 10^7$

**Table 2–12 Summary of Impacts Under Alternative 4—Construct New Research Reactor (Continued)**

		Option 1		Option 2		Option 3	
Irradiation facility		New research reactor		New research reactor		New research reactor	
Fabrication and processing facility for plutonium-238		REDC		FDPF/CPP-651		FMEF	
Fabrication and processing facility for medical and industrial isotope targets		New facility (optional)		New facility (optional)		New facility (optional)	
FFTF deactivation		Yes		Yes		Yes	
	Baseline <sup>a</sup>	Increment	Total	Increment	Total	Increment	Total
Spent fuel generation (metric tons per year)	0 <sup>c</sup>	0.31	0.31	0.31	0.31	0.31	0.31
<b>Occupational and public health and safety associated with transportation</b>							
Intersite transportation distance (million kilometers)	0	7.5	7.5	7.8	7.8	8.2	8.2
Latent cancer fatality risk increase from incident-free transportation							
Public	0	0.16	0.16	0.17	0.17	0.19	0.19
Workers	0	0.012	0.012	0.013	0.013	0.013	0.013
Nonradiological fatalities risk to public from incident-free operations	0	0.026	0.026	0.027	0.027	0.028	0.028
Latent cancer fatality risk increase to public from accident conditions	0	0.53	0.53	0.53	0.53	0.53	0.53
Nonradiological fatalities risk to public from accident conditions	0	0.19	0.19	0.19	0.19	0.20	0.20

a. Baseline impacts include contributions from the sites with currently existing candidate irradiation facilities. Baseline impacts for new candidate irradiation facilities were assumed to be zero.

b. Deactivation of FFTF results in a net decrease from the baseline of 300 site employees.

c. 2,700 metric tons of DOE spent nuclear fuel currently exist.

**Key:** NA, not applicable; NI, no or negligible impact; SP, site specific.

groundwater, it might be necessary to construct a dedicated surface water intake or wells to meet the demands of these facilities, particularly for the research reactor. As shown in Table 2–12, the option increments and corresponding totals also reflect a decrease in water use of 197 million liters (52 million gallons) annually due to permanent deactivation of FFTF. Thus, the net increases are presented.

There would be little or no additional land disturbance or associated impacts on visual resources, water use, water quality, geology and soils, ecological resources, or cultural and paleontological resources associated with target fabrication and processing in any of the existing facilities under consideration.

#### **2.7.1.1.6 Alternative 5—Permanently Deactivate FFTF (with No New Missions)**

A summary of the environmental impacts associated with Alternative 5 is presented in **Table 2–13**.

Permanent deactivation of FFTF would not involve demolition of facilities with any ground disturbance expected to be confined to the already developed areas of the FFTF complex. Therefore, no impacts on visual resources, water use, water quality, geology and soils, ecological resources, or cultural and paleontological resources are anticipated.

**Table 2–13 Summary of Impacts Under Alternative 5—Permanently Deactivate FFTF**

	Baseline <sup>a</sup>	Impacts	
		Increment	Total
FFTF at standby			
Land developed/disturbed (hectares)	18,300	0	18,300
Visual resources	NA	NI	NI
Noise	NA	NI	NI
Air quality (criteria pollutants)	NE	NI	NE
Air quality (toxic pollutants)	NE	NI	NE
Water use (millions of liters per year)	171,000	-197	170,803
Water quality	NA	NI	NI
Geology and soils	NA	NI	NI
Ecological resources	NA	NI	NI
Cultural and paleontological resources	NA	NI	NI
Socioeconomics (site employment)	28,000	-300	27,700
Environmental justice	NA	NI	NI
Occupational and public health and safety			
Latent cancer fatality risk from normal operation (35 years)			
Maximally exposed offsite individual	6.7×10 <sup>-5</sup>	1.3×10 <sup>-10</sup>	6.7×10 <sup>-5</sup>
Population	1.2	1.8×10 <sup>-5</sup>	1.2
Workforce	18.0	2.4×10 <sup>-5</sup>	18.0
Hazardous chemical risk increase from normal operation			
Cancer risk	NA	NI	NI
Hazard Index	NA	NI	NI
Latent cancer fatality risk from accidents (35 years)			
Maximally exposed offsite individual	5.7×10 <sup>-5</sup>	2.38×10 <sup>-14</sup>	5.7×10 <sup>-5</sup>
Population	0.17	1.82×10 <sup>-9</sup>	0.17
Noninvolved worker	2.4×10 <sup>-5</sup>	1.55×10 <sup>-13</sup>	2.4×10 <sup>-5</sup>
Waste generation (35 years)			
Transuranic waste (cubic meters)	78,000	0	78,000
Low-level radioactive waste (cubic meters)	590,000	0	590,000
Mixed low-level radioactive waste (cubic meters)	91,000	(b)	91,000
Hazardous waste (cubic meters)	27,000	2,500 <sup>c</sup>	30,000
Nonhazardous waste (cubic meters)	3.5×10 <sup>7</sup>	0	3.5×10 <sup>7</sup>
Spent fuel generation (assemblies per year)	0	0	0
Occupational and public health and safety associated with transportation			
Intersite transportation distance (million kilometers)	0	NA	0
Latent cancer fatality risk increase from incident-free transportation			
Public	0	NA	0
Workers	0	NA	0
Nonradiological fatalities risk to public from incident-free operations	0	NA	0
Latent cancer fatality risk increase to public from accident conditions	0	NA	0
Nonradiological fatalities risk to public from accident conditions	0	NA	0

- a. Baseline impacts include contributions from the sites with currently existing candidate irradiation facilities. Baseline impacts for new candidate irradiation facilities were assumed to be zero.
- b. Approximately 260,000 gallons of bulk sodium would be removed as a result of deactivation of FFTF. This inventory would undergo approximate excess evaluations to determine if alternate sponsors and/or uses were available and, it therefore not included in the mixed low-level radioactive waste totals for Alternative 5.
- c. Materials removed as a result of deactivation of FFTF and classified as hazardous wastes. However, these materials will be evaluated, once removed, to determine if there are any radioactive components. These materials will be reused or recycled to the extent possible.

**Key:** NA, not applicable; NE, no exceedance of air quality; NI, no or negligible impact.

Deactivation of FFTF, and possibly other supporting facilities in the 400 Area of Hanford, would eventually result in the cessation of groundwater withdrawals to meet facility cooling, potable, and sanitary needs. This would have the effect of largely eliminating the annual withdrawal of 197 million liters (52 million gallons) of groundwater. The discharge of process cooling and sanitary effluents from the facilities to onsite treatment facilities would also cease having a positive impact on treatment facility capacity.

### **2.7.1.2 Environmental Impact Comparison of Alternatives**

Tables 2–7 through 2–13 summarize the environmental effects and risks for the six alternatives evaluated in this NI PEIS. The purpose of this section is to provide comparisons of the environmental effects and risks among the various alternatives and options.

#### **2.7.1.2.1 Comparison of Radiological Risks Among the Alternatives**

For all alternatives and options, the number of incremental latent cancer fatalities would be less than one. For the purpose of analysis, incremental latent cancer fatalities were added to the baseline for expected latent cancer fatalities to obtain a total for expected latent cancer fatalities. Baseline latent cancer fatalities are discussed in Chapter 4. Values of the baseline latent cancer fatalities are driven by cumulative radiological risks at Hanford and ORNL (Table 4–1).

The information in Tables 2–6 through 2–13 shows that the largest radiological risks would result from accidents. Radiological risks to the public residing in potentially affected areas are driven by accident risks at the target fabrication and processing facilities. **Figure 2–23** shows incremental risks to the public that would result from radiological accidents (described in Chapter 4) at candidate irradiation facilities and candidate fabrication and processing facilities. The latent cancer fatalities that would be expected from radiological accidents at FMEF labeled in Figure 2–23 as “FMEF (Hanford)” are those calculated for Alternative 1, Options 3 and 6. Under Options 3 and 6 of Alternative 1, FMEF would serve as the fabrication and processing facility for all targets. If FMEF were to fabricate and process neptunium-237 targets only, the radiological accident risk to the public would be reduced by approximately a factor of two as shown by the bar labeled “FMEF (Hanford, Np<sup>237</sup> Targets Only)” in Figure 2–23. Candidate fabrication and processing facilities are shown to the left of the dividing line in Figure 2–23, and candidate irradiation facilities are shown to the right of the dividing line. Among the fabrication and processing facilities, incremental accident risks to the public range from a low of 0.0287 latent cancer fatalities at FDPF (INEEL) to 0.377 latent cancer fatalities at RPL (Hanford). Prevailing weather conditions, the geographical distribution of the population at risk, and the type of target(s) processed (plutonium-238 only, other isotopes only, or both) all contribute to variations in public accident risk. Calculations of accident consequences and risks include populations residing within 80 kilometers (50 miles) of the accident site, although the consequences and risks decrease noticeably with increasing distance from the accident site. Assuming similar source terms, accidents at sites nearest a population at risk would be expected to result in the largest risk to the public. As discussed in Appendix I, RPL (Hanford) and REDC (ORR) have the largest populations residing within 16 kilometers (10 miles) of the facility, while FDPF (INEEL) has the smallest population residing within 16 kilometers (10 miles). Risks to the public that would be expected from radiological accidents at the candidate fabrication and processing facilities are relatively large in comparison to those for the new accelerator(s), HFIR, FFTF, and the new research reactor. A more detailed description of facility accidents is provided in Sections I.1.1, Irradiation Facilities and I.1.4, Processing and Fabrication Facilities.

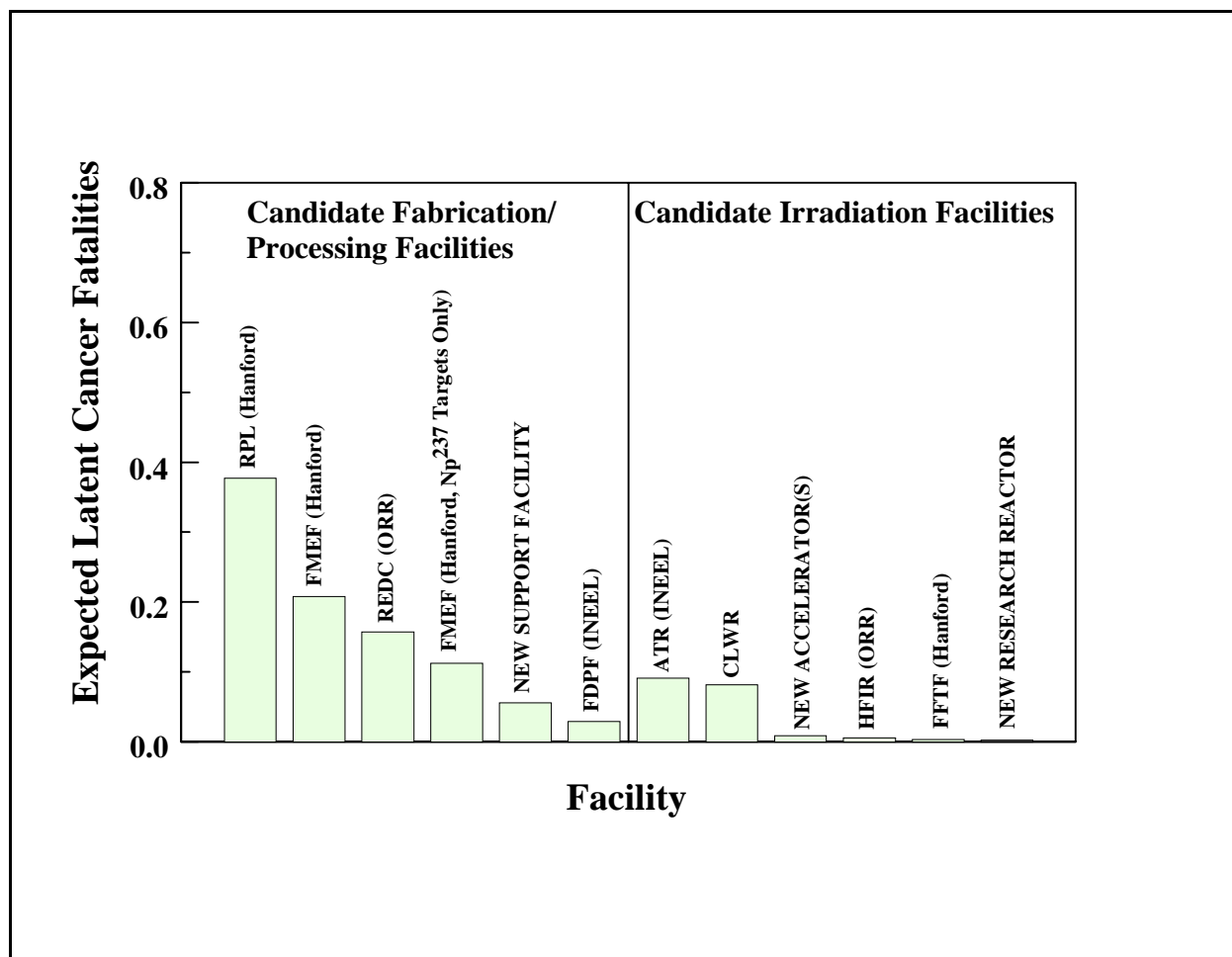


Figure 2–23 Public Risks Due to Radiological Accidents at Candidate Facilities

Figure 2–24 shows the total public risk due to accidents at the reactor and target fabrication and processing facilities for the various alternatives and options. Alternatives are listed along the horizontal axis and the total (incremental + baseline) radiological risk due to site accidents is shown on the vertical axis. The risk associated with each option under an alternative is represented by a bar whose height represents the risk calculated for that option. For the No Action Alternative and Alternative 5 (Deactivate FFTF), incremental risks are small, and the total risk nearly equals the baseline risk. Considering radiological risk to the public at the sites, Alternatives 3 (Construct New Accelerator[s]) and 4 (Construct New Research Reactor) are approximately equal. Implementation of Alternative 3 or 4 would also result in radiological risks approximately equal to those of Alternative 2 (Use Only Existing Operational Facilities). Incremental and total radiological accident risks shown in Figure 2–24 are less than one for all alternatives and options. Alternative 1 displays the widest range of accident risks among all the alternatives due to the dependance of total public risk on the selection of fabrication and processing facilities. As shown in Tables 2–6 through 2–13, normal operations at the sites would result in incremental radiological risks to the public that are typically at least three orders of magnitude less than those due to accidents at the sites.

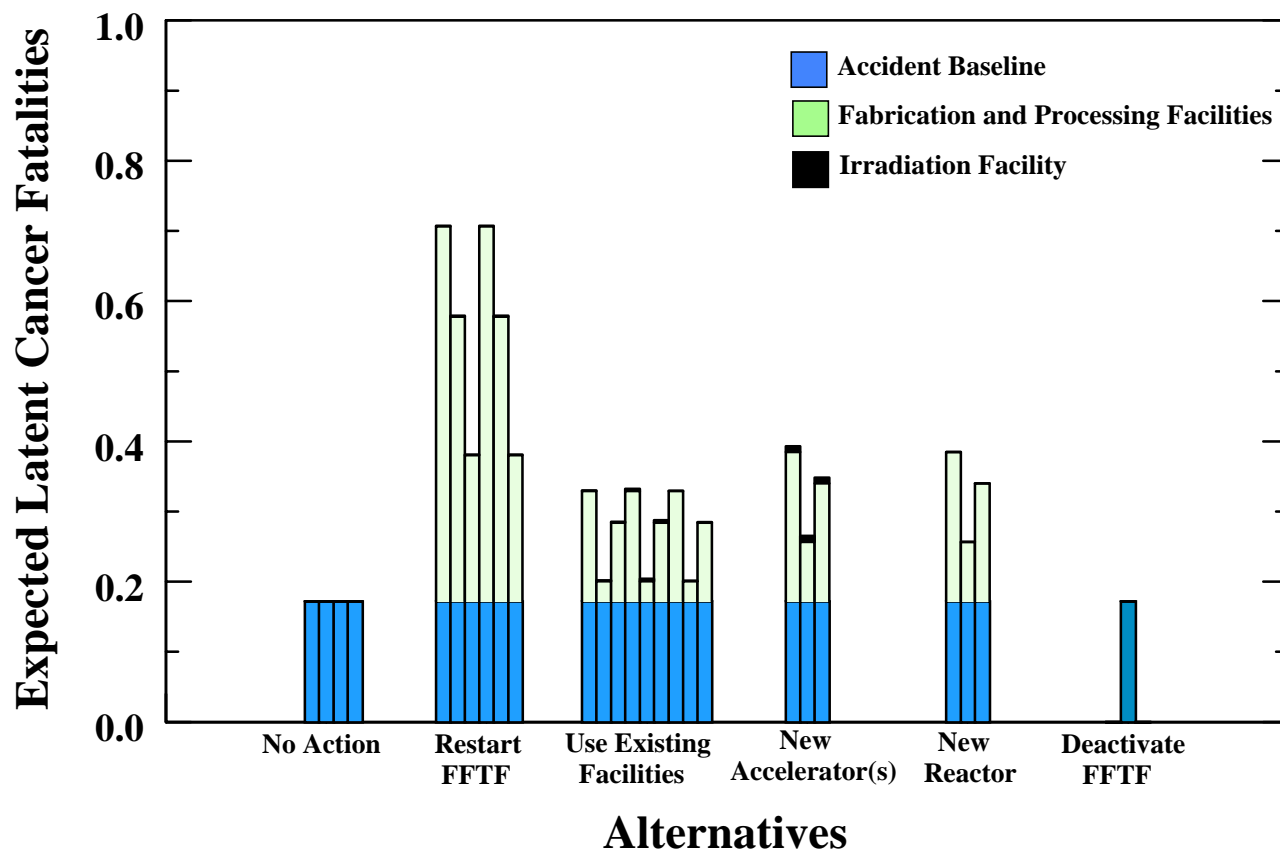


Figure 2–24 Public Risks Due to Radiological Accidents at the Sites (35 Years)

Radiological transportation risks were found to be less than one latent cancer fatality for all alternatives and options. As indicated in **Figure 2–25**, public risks due to radiological transportation accidents would be largest for Alternative 1 (Restart FFTF), Alternative 3 (Construct New Accelerator[s]), and Alternative 4 (Construct New Research Reactor). The implementation of any of these alternatives would be expected to result in over 8,000 shipments of isotopes by air transport during the 35-year program (see Appendix J). The number of airborne shipments of isotopes under the No Action Alternative and Alternative 2 (Use Only Existing Operational Facilities) would be negligible in comparison. As a result, radiological risks to the public that would result from transportation accidents under the No Action Alternative and Alternative 2 are at least four orders of magnitude less than those under Alternatives 1, 3, and 4.

**Figure 2–26** shows the radiological risk to the public that would result from incident-free transportation. For all alternatives and options the incident-free radiological risks would be less than approximately 0.2 latent cancer fatalities. As shown in the summary tables, radiological risks to maximally exposed offsite individuals and workers are small, and it would be unlikely that a latent cancer fatality would result among maximally exposed offsite individuals or workers.

#### **2.7.1.2.2 Comparison of Nonradiological Risks Among the Alternatives**

Information displayed in Tables 2–6 through 2–13 and discussed in Chapter 4 indicates that implementation of the No Action Alternative, Alternative 1 (Restart FFTF), Alternative 2 (Use Only Existing Operational Facilities), or Alternative 5 (Deactivate FFTF) would have a small impact on visual resources, noise, water quality, geology and soils, ecological resources, cultural resources, wetlands, environmental justice, and local employment. Restart of FFTF under Alternative 1 would increase groundwater use in the 400 Area of Hanford by an estimated 61 million liters (16 million gallons) annually under Option 1 or 4 and by about 79 million liters (21 million gallons) per year under Option 3 or 6. There would be a substantial decrease in groundwater usage in the 400 Area of Hanford associated with the permanent deactivation of FFTF. Under these alternatives, no new facilities would be constructed and only minor modifications to existing facilities would be required.

Implementation of Alternatives 3 (Construct New Accelerator[s]) or 4 (Construct New Research Reactor) would be conducted at a site or sites yet to be selected. If construction were to take place on undisturbed land, the Visual Resource Management Class could change from Class II or Class III (typical of undeveloped portions of many DOE sites) to Class IV. If the location were previously developed, the Visual Resource Management Class would likely remain Class IV. Regardless of the location, criteria air pollutant concentrations during construction and operation would not be expected to exceed air quality standards for criteria pollutants (see Chapter 4). Typical construction activities would result in traffic and impulsive noise that could disturb wildlife near the construction site. Clearing operations would disturb an estimated 20.2 hectares (50 acres) of land for construction of the high-energy accelerator, 4 hectares (10 acres) of land for construction of the low-energy accelerator, 4 hectares (10 acres) of land for the new reactor, and 2.4 hectares (6 acres) for the (optional) support facility.

As presented in Tables 2–11 and 2–12 and discussed in the accompanying text, the implementation of Alternative 3 or 4 would require the use of substantial quantities of water for operation of the proposed facilities. Operation of the new high-energy accelerator and new research reactor would account for the vast majority of the projected water use due to the high-cooling-water demands of these facilities. Specifically, operation of the high-energy accelerator would require an estimated 1,904 million liters (503 million gallons) of water per year, with operation of the research reactor requiring 807 million liters (213.1 million gallons) annually. Also included under both alternatives would be the permanent deactivation of FFTF resulting in a

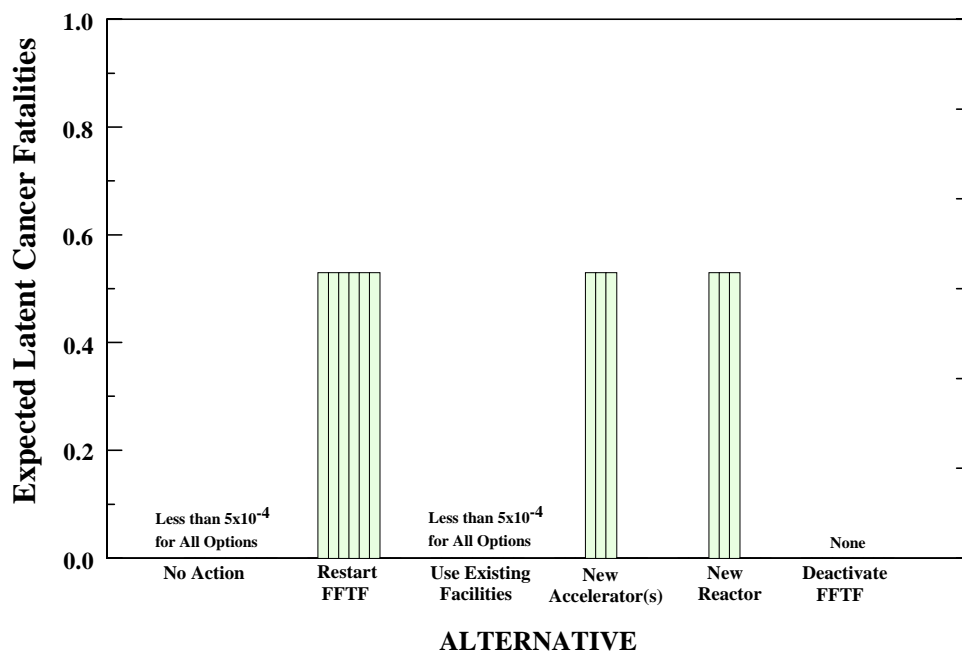


Figure 2–25 Public Risks Due to Radiological Transportation Accidents (35 Years)

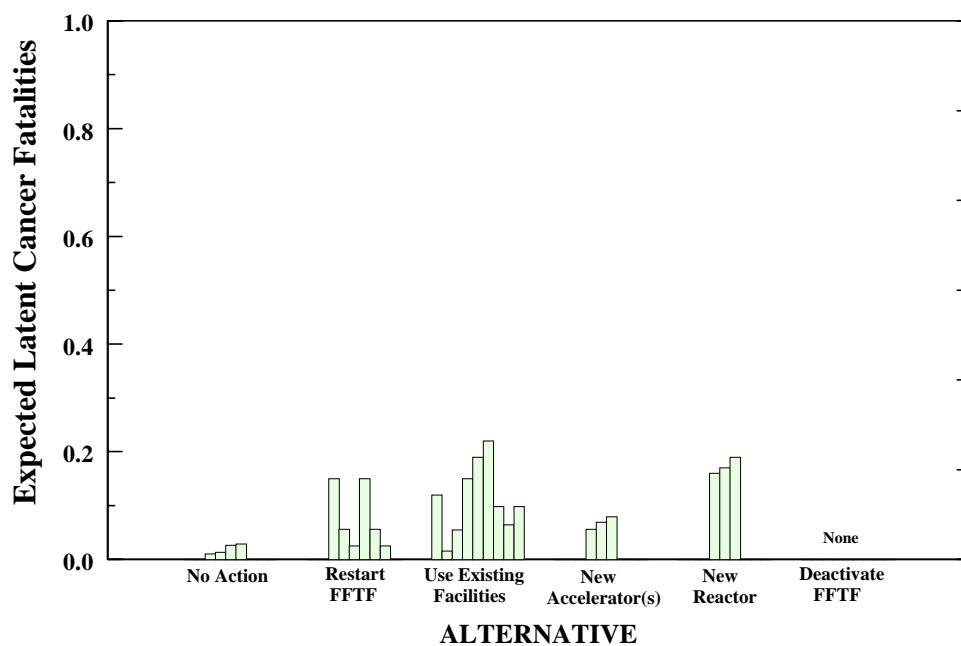


Figure 2–26 Radiological Risks to the Public Due to Incident-Free Transportation (35 Years)

reduction in water use at Hanford of approximately 197 million liters (52 million gallons) annually. This is also reflected in Tables 2–11 and 2–12 and serves to somewhat mitigate the total impacts on water use.

Construction of the facilities could result in a direct loss of wetlands, although proper site selection could avoid or mitigate the loss of wetlands. Use of undisturbed land could also impact cultural or paleontological resources. Impacts at the site(s) for new accelerator(s) or new reactor could also impact local employment sufficiently to affect regional economic conditions. Based on the estimated impacts described in Chapter 4 for Alternatives 1, 2, and 5, impacts on local employment would not be expected to significantly affect regional economic conditions. However, all of these environmental areas of concern are site dependent. If Alternative 3 or 4 were selected for implementation, additional NEPA documentation addressing site specific environmental areas of concern would be performed prior to implementation.

The analysis of air quality impacts presented in Chapter 4 included assessment of criteria pollutants and toxic pollutants using the assessment methodology described in Section G.3. Implementation of any of the alternatives and options would not be expected to exceed standards and guidelines for criteria or toxic pollutant concentrations. Hazard indexes for all options under each alternative were found to be small. Cancer risks resulting from exposure to potentially carcinogenic chemicals were found to be less than  $5 \times 10^{-7}$  under all alternatives and options. Under Options 4, 5, and 6 of Alternative 2, target irradiation would take place in an operating CLWR yet to be selected. Since implementation of Alternative 2 would not measurably increase nonradiological air pollutant emissions, no incremental air quality impacts at the reactor site would be expected. Air quality at yet-to-be-selected accelerator or reactor sites could not be evaluated in detail. In the event that Alternative 3 or Alternative 4 were selected for implementation, site-specific air quality effects would be addressed in additional environmental documentation prior to implementation.

Waste generated from Alternatives 1 through 5 could be managed by the existing waste management infrastructure and would have a minimal influence on the existing waste generation baseline. However, transuranic waste that would be generated as a result of target fabrication and processing would be ineligible for disposal at WIPP. It would be stored at the generation site pending availability of a suitable geologic repository for permanent disposal. DOE Order 435.1 requires DOE Headquarters' approval of a decision to generate nondefense transuranic waste.

**Figures 2–27 and 2–28** show the public risk that would result from vehicular collisions (without a radiological spill) and vehicle exhaust emissions, respectively. The expected number of fatalities that would result from nonradiological traffic accidents would be less than 0.2 under all options and alternatives. The expected number of fatalities that would result from vehicular exhaust emissions would be less than 0.1 for all alternatives and options. Expected fatalities that would result from vehicular collisions (without radiological consequences) and exhaust emissions are reasonably well correlated with the distances that would be traveled under the alternatives and options (see **Figure 2–29**). As discussed in Appendix J, traffic accident rates are dependent on the type of carrier. Both commercial trucks and DOE's safe, secure trailer system would be used for highway transport of isotopes. Accident rates for the safe, secure trailer system are less than those for commercial truck, so that the expected collision fatalities for any option would increase with distance traveled, but the rate of increase would depend on the relative amounts of travel by commercial truck and the safe, secure trailer system.

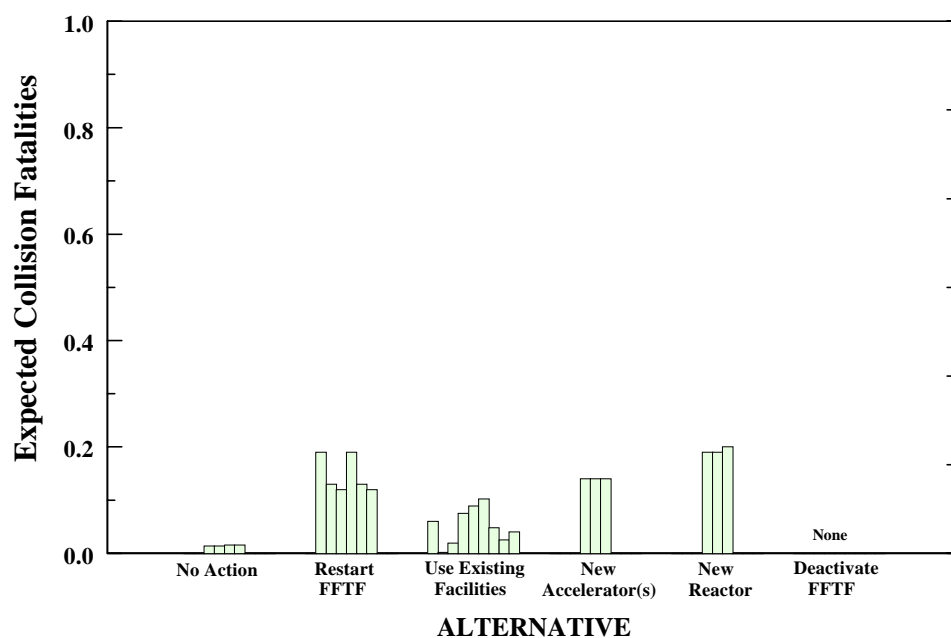


Figure 2–27 Risk to the Public Due to Vehicle Collisions Over 35 Years (Without Radiological Consequences)

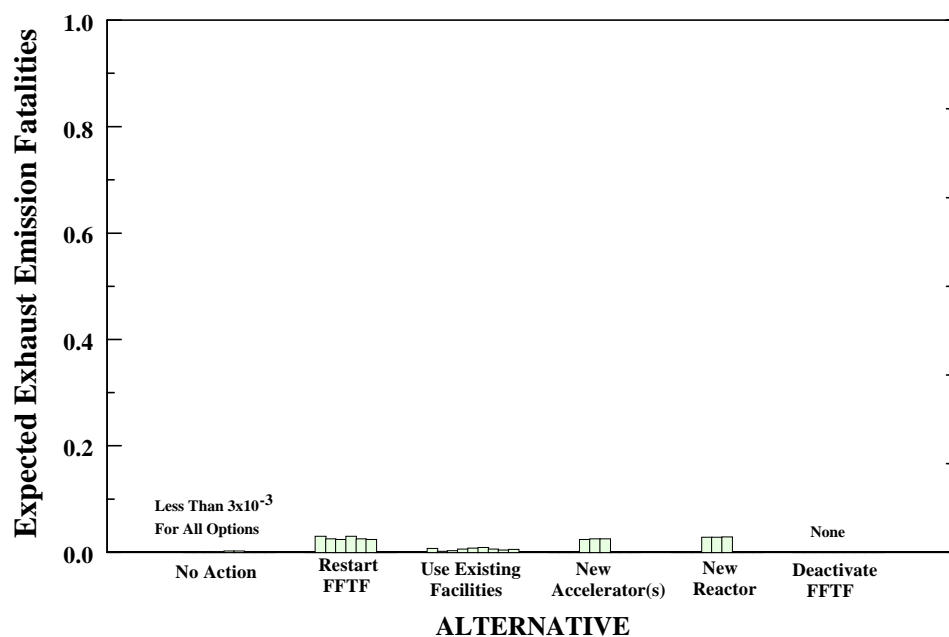


Figure 2–28 Risk to the Public Due to Exhaust Emissions (35 Years)

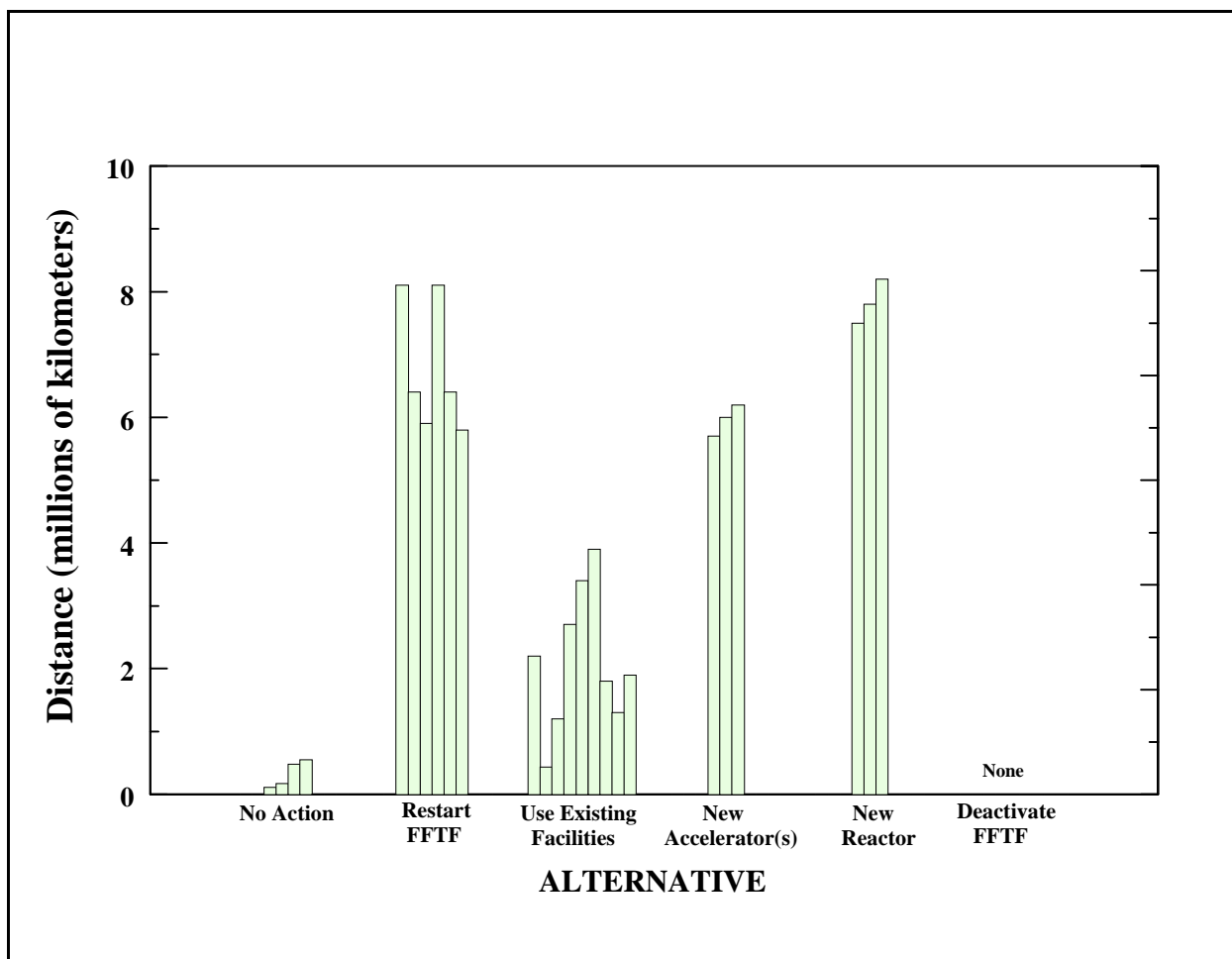


Figure 2-29 Highway Distances That Would Be Traveled Under the Alternatives (35 Years)

### 2.7.1.2.3 Comparison of Mission Effectiveness Among Alternatives

Section 2.7.1.2.3 compares the effectiveness of Alternatives 1, 2, 3, and 4 in achieving the goals of the three missions evaluated in this NI PEIS:

- Medical and industrial isotope production
- Plutonium-238 production for space mission
- Nuclear energy research and development for civilian applications

#### Alternative 1—Restart FFTF

FFTF would produce high-energy neutrons and a large flux level ( $10^{15}$  neutrons per square centimeter per second) that can be tailored to nearly any desired energy level. FFTF would provide the greatest flexibility for both isotope production and nuclear-based research and development among the baseline configurations for all of the proposed alternatives. Due to its large core size, flux spectrum, demonstrated testing capability, and rated power level, it would be able to concurrently support the projected plutonium-238 needs, production of medical and industrial isotopes, and nuclear research and development related to a broad range of materials, advanced reactors, advanced fuels, and waste transmutation.

### **Alternative 2—Use Only Existing Operational Facilities**

Due to current mission commitments at the existing DOE facilities, a large portion of the reactor irradiation space is committed to existing users. The existing reactors are able to provide for the current plutonium-238 needs. However, fulfilling this requirement with these facilities would use most, if not all, excess capacity, and may require some non-federal missions to be terminated. The ability to expand the medical and industrial isotope production would require some current missions to be postponed or terminated. If the CLWR were used for plutonium-238 production, then the existing facilities would gain additional margin for medical and industrial isotope production and limited nuclear research and development activities. These facilities have primary missions with sponsors who reserve the right to dictate to what degree and the times the facility could be used.

### **Alternative 3—Construct New Accelerator(s)**

Two accelerators, a low-energy accelerator and a high energy accelerator, are proposed for Alternative 3. The low-energy accelerator would serve as a dedicated isotope production facility. Due to the nature of this type of accelerator, it could only produce a limited number of the isotopes listed in Table 1–1, it has no ability to satisfy the plutonium-238 needs, and a limited ability to support the proposed nuclear-based research and development needs. The preconceptual design of the high-energy accelerator presented in Appendix F focused on supporting the plutonium-238 production mission. The design of the high-energy accelerator could be refined and expanded to perform additional missions such as the production of a select set of medical and industrial radioisotopes. In addition, DOE is aware of longer-term concepts that would apply high-energy accelerators to produce “tuneable” neutrons in a subcritical assembly. Such a facility could be used to address some of the missions more familiar to reactor facilities and may hold considerable promise for future science and technology research. A facility of this nature could provide unique capabilities in areas such as the testing of many different nuclear system coolant, fuel, and material interactions. The changes required to add additional capability to the high-energy accelerator could be provided, but they would increase the size of the facility, add complexity to the facility design and operation, increase the cost of construction and operation, and potentially require more time for design and construction.

### **Alternative 4—Construct New Research Reactor**

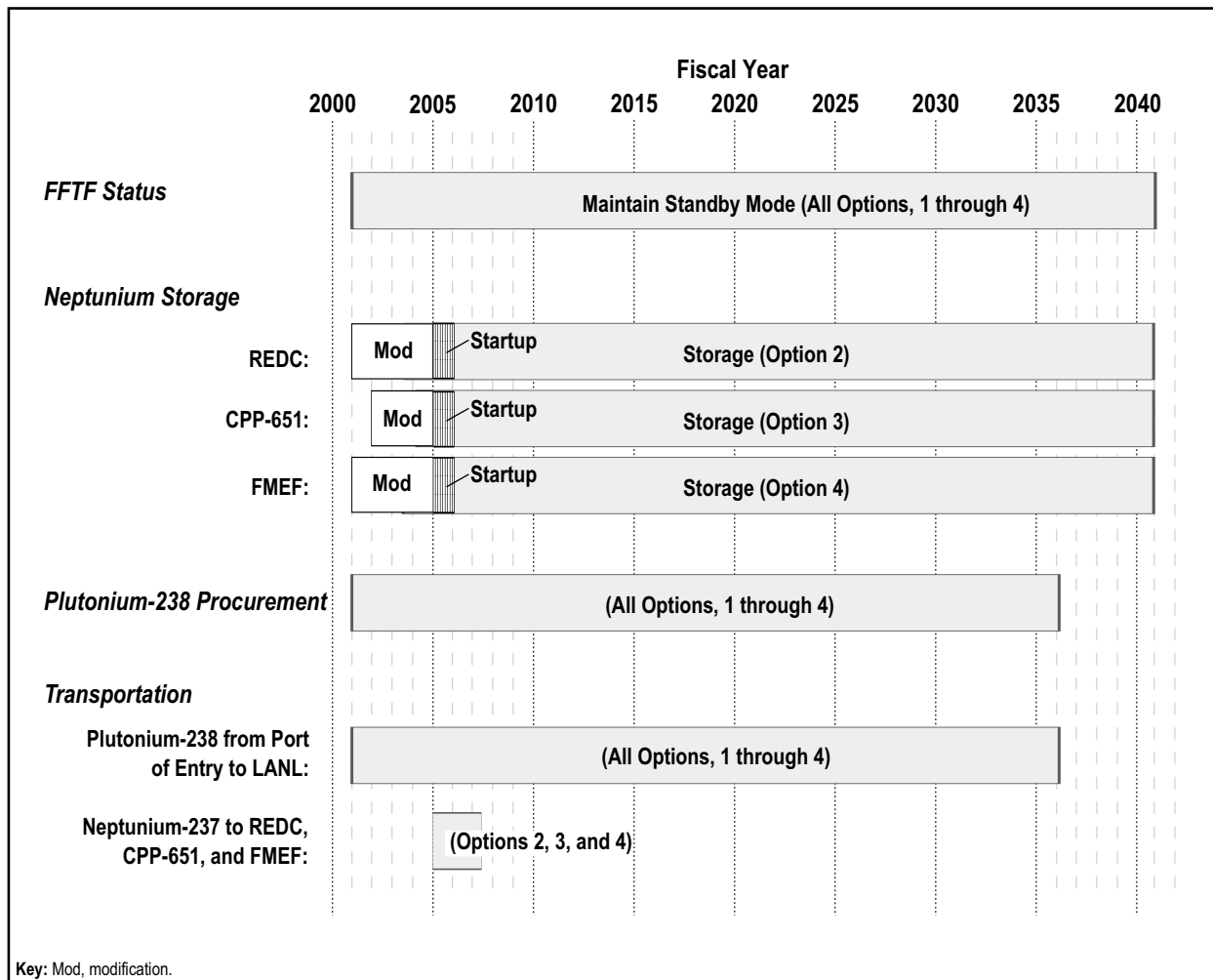
The proposed new research reactor would provide ample neutrons for the production of plutonium-238 and for many of the isotopes listed in Table 1–1. The thermal flux would limit the new research reactor's ability to produce a number of isotopes requiring fast or high-energy neutrons. Its lower flux levels ( $10^{13}$  neutrons per square centimeter per second) and predominantly thermal flux would limit its ability to support many of the projected nuclear-based research and development needs.

## 2.7.2 Implementation Schedule

The implementation schedules for the alternatives in this NI PEIS are presented in **Figures 2–30** through **2–35**.

### No Action Alternative

The implementation schedule for the No Action Alternative is shown in Figure 2–30. As indicated, the design and construction for the storage facilities would start during fiscal years 2001 and 2002 and would be completed during fiscal year 2004. Neptunium-237 shipments from SRS would take place during fiscal years 2005 to 2007. The purchase of plutonium-238 from Russia would start during fiscal year 2001.

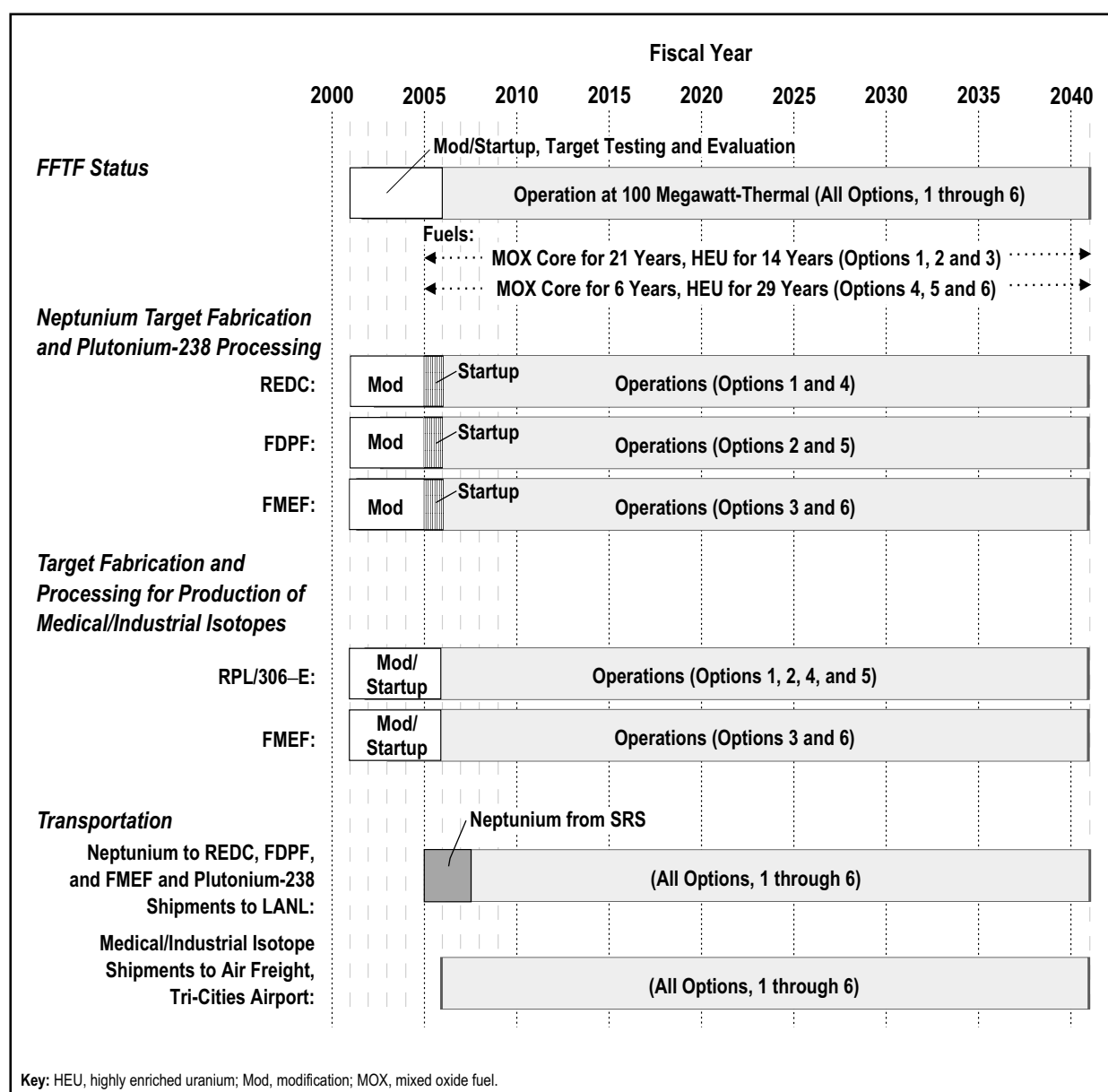


**Figure 2–30 Implementation Schedule for the No Action Alternative**

### Alternative 1—Restart FFTF

The planned implementation schedule for Alternative 1 is shown in **Figure 2–31**. As indicated, facility modification, design, and construction at target fabrication and processing facilities would take place during fiscal years 2001 to 2005.

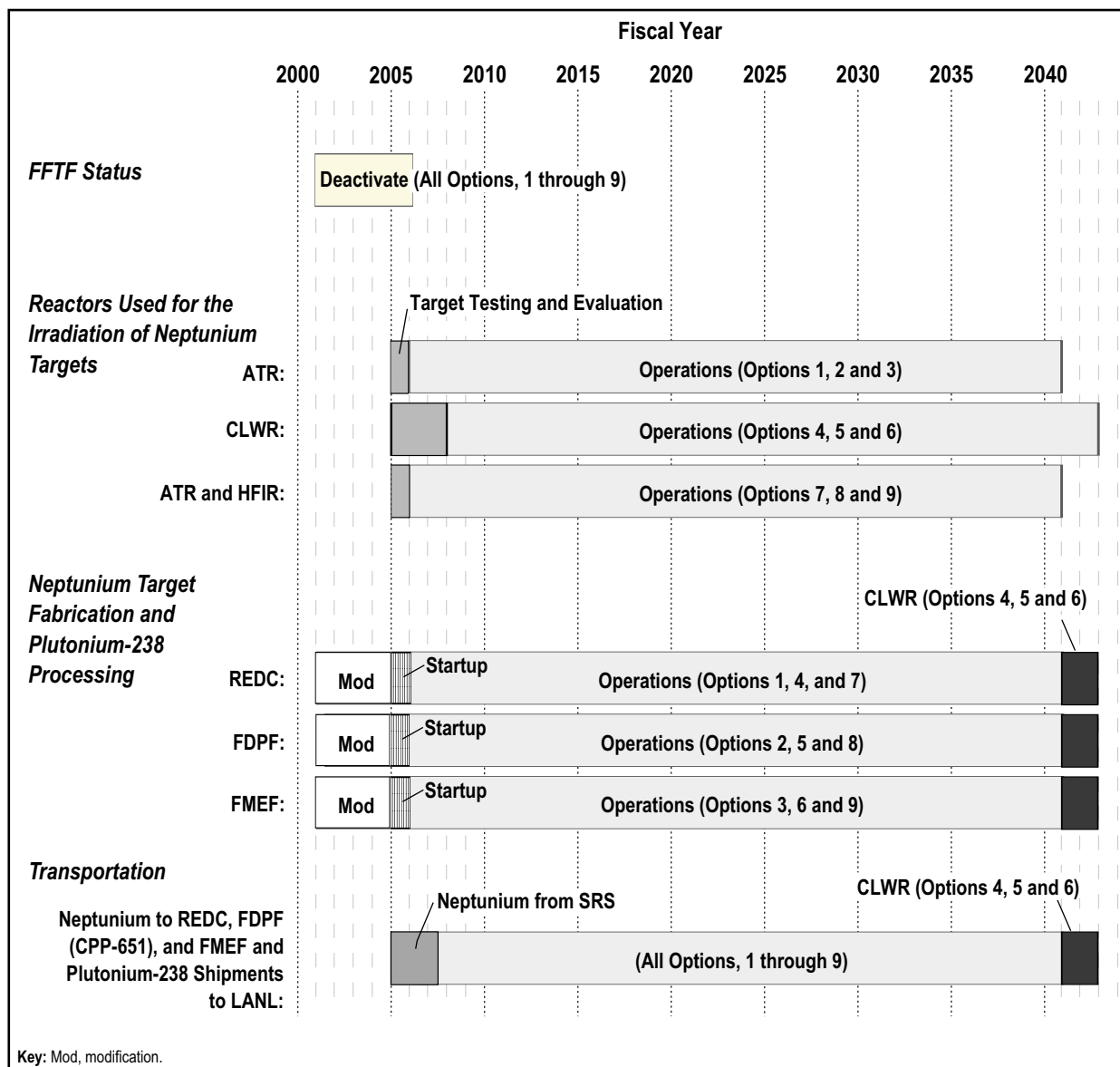
As shown in Figure 2–31, target fabrication and processing at REDC, FDPF, and FMEF were assumed to begin in fiscal year 2006 and would continue through fiscal year 2040 in conjunction with target irradiation at FFTF. Target testing and evaluation and facility testing and startup were assumed to take place in fiscal year 2005 at FFTF.



**Figure 2–31 Implementation Schedule for Alternative 1**

## Alternative 2—Use Only Existing Operational Facilities

The planned implementation schedule for Alternative 2 is shown in **Figure 2–32**. As indicated, facility modification, design, and construction at storage and target fabrication and processing facilities would take place during fiscal years 2001 to 2004. It was assumed that reactor facilities would not require any modifications to irradiate targets.



**Figure 2–32 Implementation Schedule for Alternative 2**

As shown in Figure 2–32, target fabrication and processing at REDC, FDPF, and FMEF were assumed to begin in fiscal year 2006 and would continue through fiscal year 2040 in conjunction with target irradiation at HFIR and/or ATR, and through fiscal year 2042 in conjunction with target irradiation at the CLWR. Target testing and evaluation and facility testing and startup were assumed to begin in fiscal year 2005 for each of the nuclear reactors and to continue to fiscal year 2006 at HFIR and/or ATR, and to fiscal year 2008 at the CLWR.

Irradiation operations at nuclear reactor facilities would occur from fiscal year 2006 through fiscal year 2040 at HFIR and/or ATR, and from fiscal year 2008 through fiscal year 2042 at the CLWR.

Deactivation of FFTF would begin fiscal year 2001 and continue through fiscal year 2006.

### **Alternative 3—Construct New Accelerator(s)**

The planned implementation schedule for Alternative 3 is shown in **Figure 2–33**.

The new low-energy accelerator design and construction was assumed to begin fiscal year 2001 and continue to 2004, startup would be completed during fiscal year 2004, and full operation would commence fiscal year 2005. The new support facility schedule is driven by the reactor schedule and has similar schedule milestones. The new low-energy accelerator and support facility would be decontaminated and decommissioned within 2 years after completion of the missions.

As shown in Figure 2–33, the new high-energy accelerator design and construction was assumed to begin fiscal year 2001 and continue through 2006. The 2-year startup period would be completed during fiscal year 2007, and full operation would commence fiscal year 2008. The neptunium-238 target fabrication and processing facility (REDC, FDPF, or FMEF) modification design would take place during fiscal years 2001 to 2004 and start receiving neptunium-237 from SRS during fiscal year 2005. These facilities would be in full operation supporting the new high-energy accelerator irradiation of the neptunium-237 targets during fiscal year 2008. The new high-energy accelerator would be decontaminated and decommissioned within 3 years after completion of the mission.

Deactivation of FFTF would begin fiscal year 2001 and continue through fiscal year 2006.

### **Alternative 4—Construct New Research Reactor**

The planned implementation schedule for Alternative 4 is shown in **Figure 2–34**.

The new research reactor design and construction was assumed to begin fiscal year 2001 and continue to 2008, startup would be completed during fiscal year 2008, and full operation would commence fiscal year 2009. The new support facility schedule is driven by the reactor schedule and has similar schedule milestones.

As shown in Figure 2–34, the neptunium-238 target fabrication and processing facility (REDC, FDPF, or FMEF) modification design would take place during fiscal years 2001 to 2004 and start receiving neptunium-237 from SRS during fiscal year 2005. These facilities would be in full operation supporting the new reactor irradiation of the neptunium-237 targets during fiscal year 2009. The new research reactor and support facility would be decontaminated and decommissioned within 8 years after completion of the missions.

Deactivation of FFTF would begin fiscal year 2001 and continue through fiscal year 2006.

### **Alternative 5—Permanently Deactivate FFTF (with No New Missions)**

The planned implementation schedule for Alternative 5 is shown in **Figure 2–35**. As indicated, deactivation of FFTF would take place over 5 years (Battelle 1999).

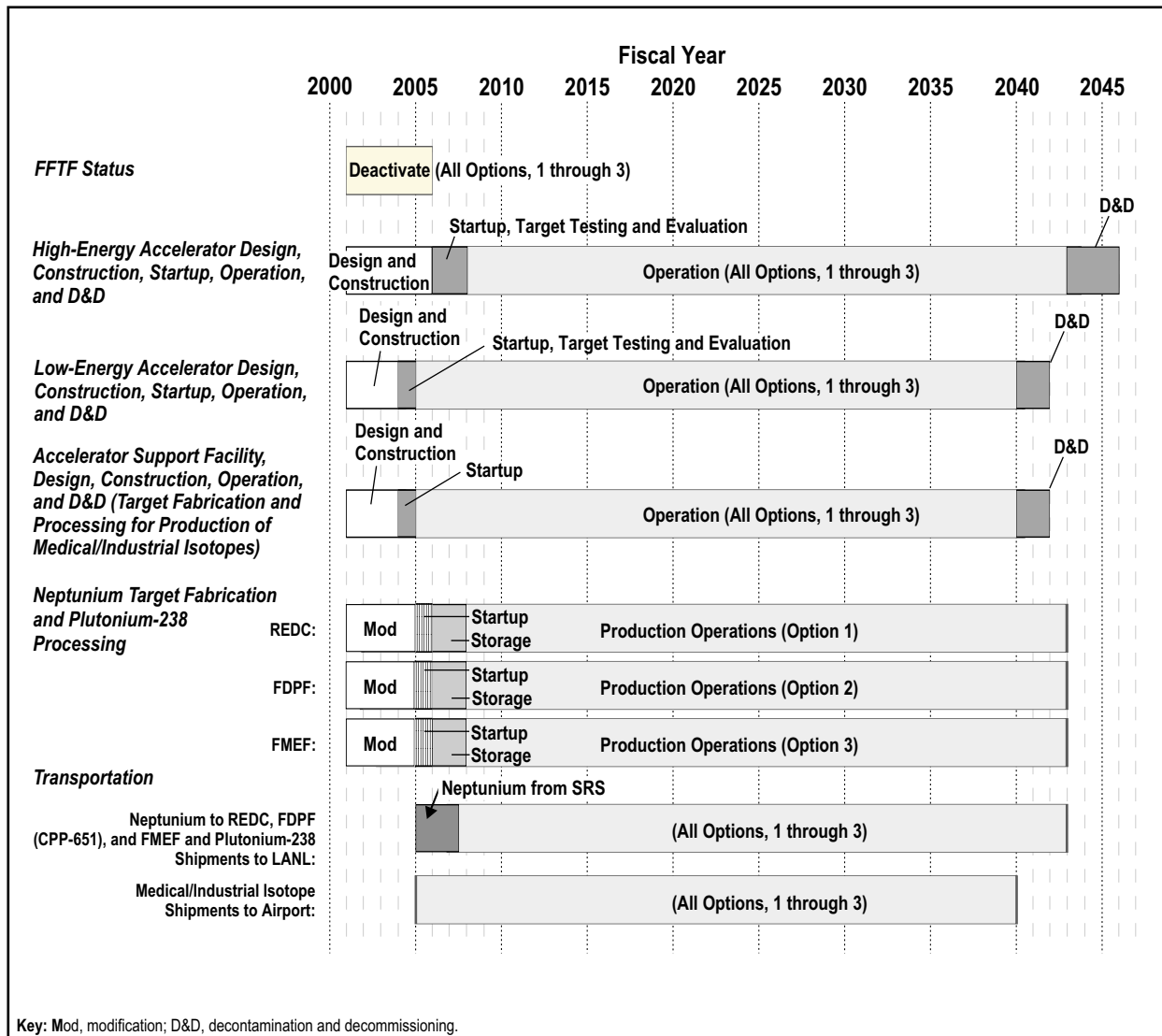


Figure 2-33 Implementation Schedule for Alternative 3

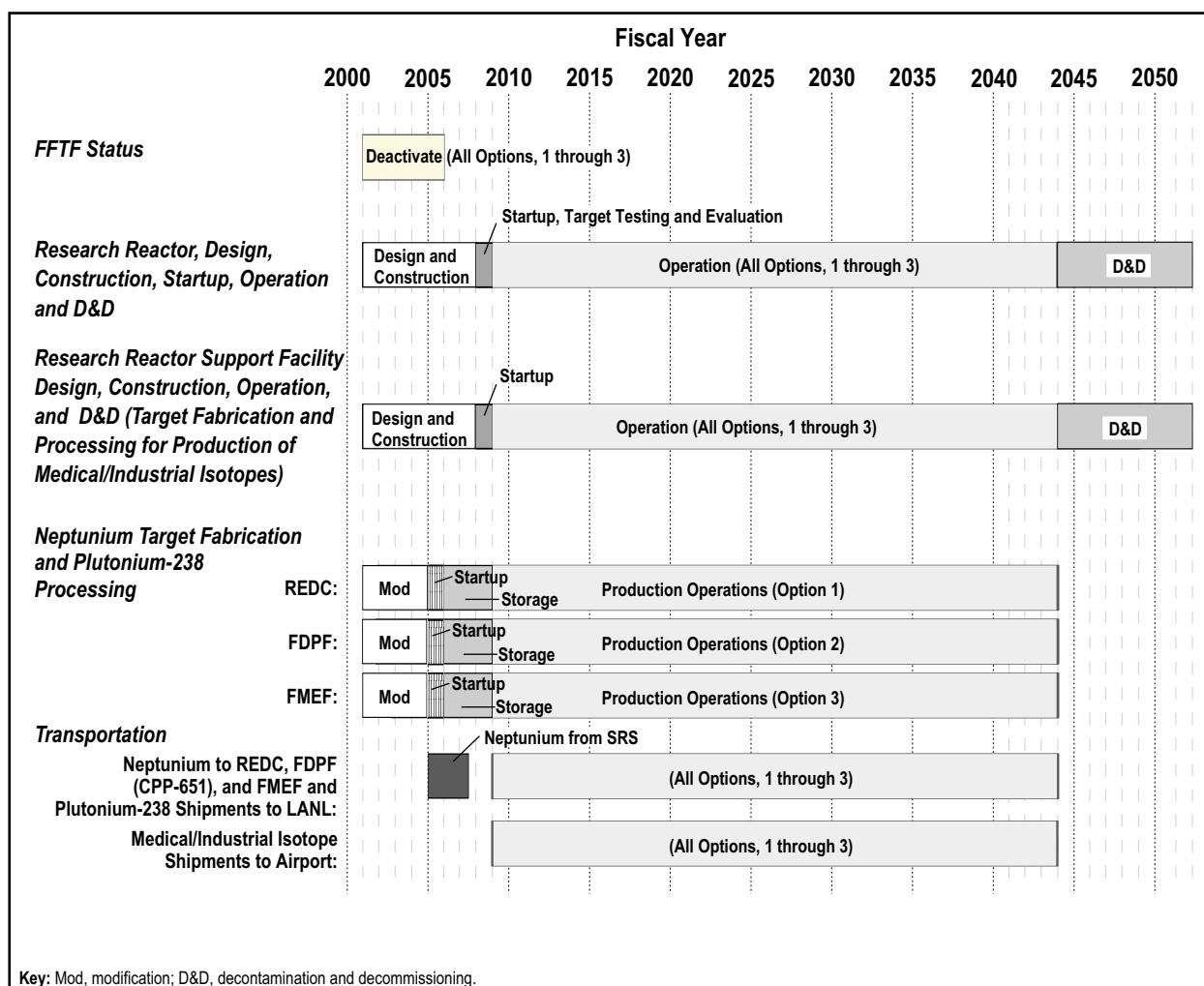


Figure 2-34 Implementation Schedule for Alternative 4

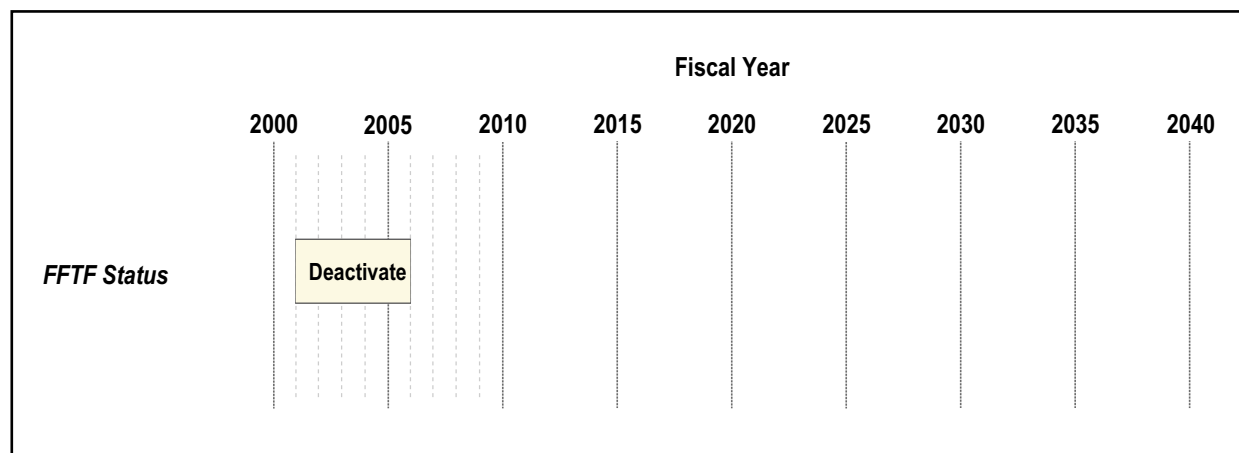


Figure 2-35 Implementation Schedule for Alternative 5

## **2.8 PREFERRED ALTERNATIVE**

Council on Environmental Quality regulations require an agency to identify its preferred alternative(s), if one or more exists, in a draft PEIS (40 CFR Section 1502.14e). According to the regulations, a preferred alternative is defined as the alternative the agency believes would fulfill its statutory mission, giving consideration to environmental, economic, technical, and other factors.

This NI PEIS provides information on the environmental impacts and schedule related to each of the proposed alternatives. A preferred alternative, however, has not yet been identified. In accordance with the Council on Environmental Quality regulations, the Final NI PEIS will identify the preferred alternative.

## 2.9 REFERENCES

### Code of Federal Regulations

10 CFR Part 71, “Packaging and Transportation of Radioactive Materials,” U.S. Nuclear Regulatory Commission.

40 CFR Section 1502.14e, “Alternatives Including the Proposed Action,” U.S. Environmental Protection Agency.

49 CFR Part 173, “Shipping - General Requirements for Shipping and Packaging,” U.S. Department of Transportation.

### Federal Register

44 FR 1957, Executive Office of the President, 1979, “Executive Order 12114 - Environmental Effects Aboard of Major Federal Action,” p. 356, January 4.

62 FR 61099, U.S. Department of Energy, 1997, “Interim Management of Nuclear Materials at the Savannah River Site,” November 14.

### Congressional Record

U.S. House of Representatives, 1992, *Conference Report on H.R. 776, Comprehensive National Energy Policy Act* (Schumer Amendment), H12103, Washington, DC, October 5.

### Other References

AEC (U.S. Atomic Energy Commission), 1972, *Environmental Statement, Fast Flux Test Facility*, Wash-1510, Richland, WA, May.

AECL (Atomic Energy of Canada Limited), 1996, *Environmental Screening Report for the Medical Isotope Project*, Ottawa, Canada, October 28.

ANSTO (Australian Nuclear Science and Technology Organization), 1999, *Supplement to the Draft Environmental Impact Statement for the Replacement Nuclear Research Reactor*, January 18.

Battelle (Battelle Memorial Institute), 1999, *Program Scoping Plan for the Fast Flux Test Facility*, PNNL-12245, rev. 1, August.

BWHC (B & W Hanford Company), 1999, *Hanford Data Request for FFTF Operational Support Facilities*, Richland, WA, October 6.

DOE (U.S. Department of Energy), 1993, *Environmental Assessment of the Import of Russian Plutonium-238*, DOE/EA-0841, Office of Nuclear Energy, Washington, DC, June.

DOE (U.S. Department of Energy), 1995a, *Environmental Assessment - Shutdown of the Fast Flux Test Facility, Hanford Site, Richland, Washington*, DOE/EA-0993, Richland Operations Office, Richland, WA, May.

DOE (U.S. Department of Energy), 1995b, *General Description of Fuels and Materials Examination Facility (FMEF)*, Richland Operations Office, Richland, WA, June 16.

DOE (U.S. Department of Energy), 1995c, *Final Environmental Impact Statement, Interim Management of Nuclear Materials at the Savannah River Site*, DOE/EIS-0220, Savannah River Operations Office, Aiken, SC, October.

DOE (U.S. Department of Energy), 1996, *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel*, DOE/EIS-0218F, Office of Environmental Management, Washington, DC, February.

DOE (U.S. Department of Energy), 1997, "Extension of Contract with the Mayak Production Association," mod. A004, DE-AC01-93NE32169, Washington, DC, December 11.

DOE (U.S. Department of Energy), 2000a, *Nuclear Science Technology Infrastructure Roadmap*, Draft, rev. 1, Office of Nuclear Energy, Science and Technology, Washington, DC, March 24.

DOE (U.S. Department of Energy), 2000b, *Waste Minimization and Management Plan, Fast Flux Test Facility Hanford Site, Richland, Washington*, Revised Draft, Office of Nuclear Energy, Science and Technology, Washington, DC, May.

Hochhalter, E.E., 1982, *Fluorinel Dissolution Process and Fuel Storage Facility Radiation Shielding Design and Analysis*, rev. 1, ENI-151, U.S. Department of Energy, Idaho Operations Office, Idaho Falls, ID, August.

Hoyt, R.C., R.J. Venetz, J.A. Teal, D.C. Lini, R.E. Barker, L. Rodgers, C. Hawk, M.D. Crippen, and J.M. Tingey, 1999, [DL-0176] *Summary of Strategy for Implementing Plutonium-238 Production Support Activities in FMEF*, U.S. Department of Energy, Richland Operations Office, Richland, WA, May 12.

IAEA (International Atomic Energy Agency), 1997, *The Convention on the Physical Protection of Nuclear Material*, INFCIRC 274, rev. 1, add. 6, February.

IAEA (International Atomic Energy Agency), 1999, *The Physical Protection of Nuclear Material*, INFCIRC 225, rev. 4 (corrected), June.

IMO (International Maritime Organization), 1993, *Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium-238 and High-Level Radioactive Wastes in Flasks on Board Ships*, Resolution A.748(18), November 4.

INEEL (Idaho National Engineering and Environmental Laboratory), 1999, *Nuclear Materials Inspection and Storage Facility Safety Analysis Report*, Issue 06, July.

INEEL, 2000, *Advanced Test Reactor Critical Facility Safety Analysis Report and Technical Specifications*, Issue 0, INEEL/EXT-2000-00765 (SAR-30), Idaho Falls, ID.

LMER (Lockheed Martin Energy Research Corporation), 1998, *High Flux Isotope Reactor Safety Analysis Report*, ORNL/M-2344/RO, Oak Ridge National Laboratory, Research Reactors Division, Oak Ridge, TN, July 10.

LMIT (Lockheed Martin Idaho Technologies Company), 1997, *Advanced Test Reactor, Upgraded Final Safety Analysis Report*, Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID, July 1.

LMIT (Lockheed Martin Idaho Technologies Company), 1998, *Capabilities of the Test Reactor Area Featuring the Advanced Test Reactor*, BP297-RO895-5M-T, Idaho Falls, ID.

McCallum, E.J., 1999, U.S. Department of Energy Office of Safeguards and Security, Memorandum to Distribution, *Protection of Separated Neptunium-237 and Americium*, Germantown, MD, February 11.

Nielsen, D.L., 1999, *Fast Flux Test Facility Data Request in Response to Data Call for Nuclear Infrastructure Programmatic Environmental Impact Statement*, BWHC-9958233, B & W Hanford Company, Richland, WA, December 21.

ORNL (Oak Ridge National Laboratory), 1998, *High Flux Isotope Reactor Facility Description*, [www.ornl.gov/hfir/hfir1.html](http://www.ornl.gov/hfir/hfir1.html), Oak Ridge, TN, November 15.

SAIC (Science Applications International Corporation), 2000, *Response to the Data Request for the Generic Facility to Support the DOE Accelerator or Research Reactor Alternatives*, Richland, WA, July 13.

TEC (Toledo Edison Company), 1996, *Final Safety Analysis Report, Davis-Besse Nuclear Power Station*, rev. 20, NRC Docket 50-346, Toledo, OH, December.

TechSource (TechSource, Inc.), 2000, *Nuclear Infrastructure PEIS Data Submittal for Accelerators*, Santa Fe, NM, June 29.

Wham, R.M., W.D. Bond, E.D. Collins, L.K. Felker, W.D. Garrett, J.B. Knauer, J.H. Miller, F.L. Peishal, R.G. Stacy, R.J. Vedder, and O.O. Yarbrow, 1998, *Preconceptual Design Planning for Chemical Processing to Support Pu-238 Production*, rev. 0, Oak Ridge National Laboratory, Oak Ridge, TN, September.